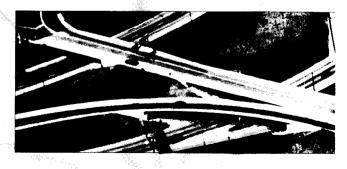
NATIONAL CONFERENCE ON INTELLIGENT TRANSPORTATION SYSTEM AND THE ENVIRONMENT: CONFERENCE PROCEEDINGS











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PREFACE

Executive Summary

The purpose of the National Policy Conference on ITS and the Environment was to conduct a wide ranging examination of how intelligent transportation and related advanced technologies could impact environmental policies and principles. The conference program was organized around four areas: 1) new strategies and technologies, 2) energy and environmental implications, 3) institutional issues, and 4) societal implications. The conference included twenty-three commissioned papers across the four general categories; eight of the commissioned papers were presented during the full sessions of the conference. Over the two day program, the conference featured the visions and perspectives of many different experts and explored many cooperative possibilities to address the environmental aspects of intelligent transportation systems.

Through the course of plenary panel presentation and breakout group discussions, the conference produced a set of policy, research and institutional issues that will likely set the agenda for future action. In the area of new strategies and technologies, attendees found that, although the transportation and the environmental communities do not now share a common vision, there was affirmation to strive for a common multi-modal vision for ITS. The institutional mechanism for accomplishing this would be to mainstream environmental and other public interest groups into policy discussions. Such concrete action should include a mechanism for public involvement, recognize regional diversities, and address equity issues. Conference attendees were in agreement that a strengthened MPO process was the appropriate mechanism to incorporating these concerns into the ITS deployment decisions.

With regard to the energy and environmental implications of ITS, there was broad agreement on the need for better modeling and empirical data on the magnitude of such effects, as well as the need for a better understanding of how such impacts may vary across ITS user bundles. In a related manner, representatives of the private sector expressed concern that ITS development not be held "hostage" to the environmental review process, and that a "no regrets" approach be taken which allows for rapid development of environmentally-benign ITS technologies. Finally, there was widespread agreement that assessment of ITS include not only the impacts on the physical environment, but on the larger social environment as well. These latter issues include possible neighborhood impacts of ITS, as well as the distributional implications of deployment decisions.

Background

Two previous conferences addressed intelligent transportation systems and the environment, Asilomar and Diamond Bar. Asilomar, held in April 1992, was the first exploration of the interaction between intelligent transportation systems and the environment. Diamond Bar, in March 1993, determined that there was more to the relationship than just air quality and transportation modeling and that there were wide ranging policy questions to be addressed. Thus, the first National Conference on Intelligent Transportation Systems and the Environment was conceived as a means of facilitating a broad range of discussions on the policy issues of intelligent transportation technologies and the environment.

Key Policy Issues

The specific objectives of the National Policy Conference on ITS and the Environment were broadly defined into 1) New Strategies and Technologies, 2) Energy and Environmental Implications, 3) Institutional Issues, and 4) Societal Implications. Through the contribution of all attendees and the efforts of the task group leaders in the four areas, the conference produced a set of policy, research and institutional issues that will likely set the agenda for future action. The conference included twenty-three commissioned papers in the four general categories. The conference planning issued a call for papers late in 1993. Abstracts and proposals were received from over fifty authors and institutions. The conference planning committee, acting as a screening panel, commissioned selected papers for possible presentation and publication. Eight of the commissioned papers were presented during full session of the conference. All other papers were presented at an Authors Roundtable on the first day of the conference. All papers commissioned for the conference are included in the Conference Proceedings.

Sponsors and Participants:

Sponsors

Funding sponsors included: ITS America, The California Department of Transportation, The Institute of Public Policy at George Mason University, and the State and Local Policy Programs of the Hubert H. Humphrey Institute of Public Affairs at the University of Minnesota.

Sponsorship was also provided by the Environmental Defense Fund, the Surface Transportation Planning Project, the Environmental Protection Agency, and the US. Department of Transportation, all of which provided speakers and other in-kind assistance. The Institute for Applied Social and Policy Research at Claremont Graduate School assisted with the proceedings publication.

Participants

Over 140 registrations were received prior to the start of the conference. By the end of the conference, over 155 were registered. Additionally, many of the sponsoring agencies provided speakers and participants that contributed to the broad reaching policy issues addressed during the two days of the conference. Fully one-third of the attendees identified themselves as members of, or affiliated with, environmental groups or environmentally focused interest groups. Finally, over 200 attendees participated in some or all conference activities during the two days. A complete list of registered attendees is included and may be found as an enclosure to the proceedings. Active participants are identified in the conference proceedings and the program schedule.

The conference planning committee thanks CALTRANS, George Mason University, the University of Minnesota, and Intelligent Transportation Systems, America for the generous support that made the conference possible.

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WELCOME

Tom Horan, Conference Chair Senior Fellow, George Mason University

DR. HORAN: Thank you very much for being here so bright and early on Monday of what promises to be a long, and certainly promising, two days.

I am Tom Horan, a Senior Fellow at the Institute of Public Policy at George Mason University. I have had the privilege of being one of the organizers for this conference. As many of you are aware, this conference represents the culmination of a series of activities that has led to increasing attention to the environmental aspects of intelligent vehicle highway systems and, as we have called it and it is now becoming, intelligent transportation systems.

This effort started with questioning some assumptions about the possible impacts of ITS on the environment. We held a conference on those impacts at Asilomar two years ago. Some of you were there. At that conference, we started to explore the interaction between ITS and the environment. We realized that there were a host of technical aspects to the question. Last year, we followed up in Asilomar with a conference on ITS and air quality where we looked at some of the technical modeling issues and elements to that important question.

At that conference, and in ensuing discussions, we realized that there was more to the issue than just air quality and transportation modeling. Hence we conceived of a wide-ranging discussion of the impacts of various advanced technologies on different aspects of the environment, including air quality, energy, urban form. That is really what we are here to do. As you will see on the program, we have taken it from the top--the vision for ITS. We will move from a consideration of the vision to some of the programmatic details. After our keynote speakers at lunch, we take up some of the papers that have been prepared, and then move on to breakout sessions this afternoon. Tomorrow we look at some of the institutional and research issues associated with the ITS and environment issues and then conclude with work groups developing recommendations.

We have representatives from various stakeholders and cosponsors that are here this morning to make some introductory remarks. Before I introduce to them, let me first express my thanks to the various cosponsoring organizations that include the Department of Transportation, the Surface Transportation Policy Project, the Environmental Defense Fund, ITS AMERICA, the California Department of Transportation, George Mason University and the University of Minnesota. To these organizations and other organizations I express my thanks and the thanks of the Committee for their cosponsorship. I would, also, like to thank the various representatives from this group who served on our Steering Committee.

First, I would like to ask Denny Judycki to make his opening remarks. Mr. Judycki is the Associate Administrator for Safety and Systems Applications at Federal Highways Administration. As many of you know, that is the lead office for ITS in the Department, and Denny is the lead spokesperson for that office.

CHARGE TO THE PARTICIPANTS

Dennis Judycki Associate Administrator, Safety and Systems, FHWA

MR. JUDYCKI: Thank you, Tom. It is a pleasure to be here. On an earlier program you saw that we had hoped that you would be able to meet and hear the new Director of our Joint Program Office. We do not have a Director of the Joint Program Office yet, but I think it is worthy to note that we have established a new ITS Joint Program Office in the Department reporting directly to the Federal Highway Administrator. We are in the process of filling that position. We are very excited about that and hope that it will happen very soon.*

I, also, would like to take just a moment to congratulate George Mason University and the rest of FHWA's cosponsors for all of the work that has gone into putting this together. This is an important dialogue for us to continue, and I can assure you from the departmental perspective that it will have a great deal of influence on how we manage the federal program.

It is extremely important that, through these series of meetings and discussions, we share what should be a common vision to how we are going to deal with the technology in the future, working towards a more intelligent transportation system, looking at not only safety, mobility, but environmental challenges and issues, productivity issues as well, and importantly, something I will talk again about a little later, mainstreaming within the congestion management process and the local and, state and local decision-making process, the development of projects and programs associated with what we are now calling ITS.

Earlier today somebody said, "Are we going to talk about anything we have not already talked about?" I think so. I think that there is an opportunity to walk away with that value added that we have not previously seen. Certainly better information, being better informed, an increasing understanding of where we should be coming from in dealing with transportation and the environment will be a product of this session. But in addition to that, I really think we need to provide some focus. Let us focus on how to take the next steps to enhance communication, a thoughtful process of making some progress and continually assessing where we are in the implementation of the ITS program and deployment of those strategies that are associated with it. We should assess it from the policy perspective, from the technical perspective, and from the institutional perspective as well.

So, my charge would be not to miss these two days as they provide a real opportunity to walk away with not only better information but, also, to set forth an agenda of action as to where we should go next. It is critical that we achieve this, especially if we are going to take the time of all of you who have lots of valuable things to do.

 $Good\ luck\ over\ the\ next\ two\ days,\ and\ I\ certainly\ look\ forward\ to\ working\ with\ you\ as\ we\ proceed\ through\ the\ workshops.$

DR HORAN: Thank you very much, Denny. Next, I would like to ask Dave Burwell to share a few thoughts. Dave is fresh from a three-day clambake marathon at Woods Hole, and tells me he never wants to eat another clam in his life, but with that in mind he will make his opening remarks.

* On June 24, Federal Highway Administrator Rodney Slater announced that Dr. Christine M. Johnson had been selected as the director of DOT's Joint ITS Program Office.

David Burwell President, Rails to Trails Conservancy

MR. BURWELL: I learned last week that the presenters at this conference were asked to submit their remarks two weeks ahead of time. I was a little alarmed and I asked my friend Hank Dittmar if he had complied with that rule, and he said, "Oh, no, that rule does not apply to us. Our remarks are non-substantive."

Despite that comment, I would like to say that STPP is very pleased to be a cosponsor of this conference, and we hope to lend something of substance to its conclusions. I would like to try to put a framework for analysis for this discussion on ITS and their implications for the environment. This framework consists of three points. First, ITS is here to stay. From an environmental perspective it makes no sense to debate whether ITS is good or bad and whether we should fight it or embrace it. If history teaches us anything about the human species and our pursuit of knowledge it is that technology happens. If we can dream it, we want to build it. Couple this human imperative with the fact that the Federal Government is putting between 250 and 300 million dollars annually into ITS research, development and deployment, that private industry is more than matching this amount, and that our international competitors are moving even faster to dominate the ITS market -- the future is obvious. This train is well out of the station. If environmentalists want any say in setting its destination, we had better get on board.

Second, ITS is potentially very good news for the environment. The key word in the statement, obviously is potentially. ITS, like all technologies, is neither good nor bad. It depends on how it is applied. Whether the technology is steam locomotion, the internal combustion engine or nuclear power, how we approach and handle its development makes all the difference. More specifically the good news about ITS and the environment is that it holds the promise of allowing us to take operational control of our transportation system. Too often we have put all our intellectual effort into giving birth to a new technology and then have just thrown it on the market without any thought on the implications of its application, i.e., the ready, aim, fire approach.

Similarly, we often build highways and then walk away from the resultin, strip development, congestion and general uglification of America that results. That is not our problem is the excuse. Barney Frank, a Congressman philosopher from Massachusetts; we seem to be Massachusetts intensive here today, once described the right-to-life movement as having a burning interest in the sanctity of life, an interest that begins at conception and ends at birth. The same could be said about our federal highway program over the last 40 years. Great interest in giving birth to new projects but disregard, borderin, on callous disinterest in the resulting societal consequences.

ITS can change all that. ITS can integrate trip making, allowing commuters to make just-in-time connections across modes. ITS can provide real-time feedback on the efficiency of various transportation control measures in changing travel behavior in a socially beneficial manner. ITS can help increase the variable costs of single occupancy vehicle trips while reducing fixed costs, thus encouraging consumers to act efficiently in their utilization of transportation services. and ITS could be an enormously useful mechanism for integrating clean air, land use and transportation planning.

In short, the environmental promise of ITS is an efficient and integrated transportation system where ITS technologies provide constant real-time data on system performance against a variety of societal objectives where access to transportation is fairly distributed across all income and social levels, where individual choice of mode is maximized, and where pricing signals are applied to internalize costs and discourage waste.

All these benefits require operational control of our transportation system and ITS can make it happen but not necessarily, and that is my third and last point which is the truism that every problem starts as a solution. ITS is now perceived as a solution, but what is the problem? The ITS developers are focused in a laser-like fashion on primarily two targets, safety and congestion. However, since studies show that accidents cause about 60 percent of urban congestion it all comes down to safety. Unless ITS planners, also, incorporate societal goals, such as clean air, livable communities, equity, improved competitiveness and sustainable development into the very core of the ITS program, we are likely to end up with technologies that are either illegal under the Clean Air Act or some other law

or unfundable because they primarily benefit the affluent commuter who can afford the technology while trying to distribute the cost across the entire tax base. If this happens, the huge ITS effort will be producing a lot of technology with few useful applications.

In conclusion, let me repeat my two non-substantive points. First, ITS is here to stay. Second, it holds great promise in its potential applications to promote environmental objectives. Third, ITS in its present state of development is not realizing that promise. In fact, if it continues along its present course, it is a solution potentially developing into an enormous problem. A wise man once observed that the key to a happy life is to find out what we believe in and live a life that shows it. In a similar vein, we could say about ITS, find out what we want our communities to look like and use ITS to help create it. ITS can play a large part in the promotion of livable, sustainable communities or become one of the biggest barriers to their realization. Let us start right here to make sure that ITS is the solution, not the problem.

DR. HORAN: Third and finally, Phil Shucet is here representing ITS AMERICA. While Phil isn't from Massachusetts, he does have other redeeming credentials. They include being Assistant Vice President at Michael Baker and significantly, Chair of the ITS AMERICA Energy and Environment Task Force.

Philip Shucet Assistant Vice President, Michael Baker, Jr., Inc. & ITS AMERICA Energy & Environment Committee Chair

MR. SHUCET: Welcome on behalf of ITS AMERICA to this conference and I ask you to grant me one small wish during the next two days. That is to please -- listen, listen and listen. Denny Judycki remarked that someone had said to him out in the hall, "Are we going to talk about some of the same things that we have already talked about?" Yes, probably. We probably will talk about a lot of the same things that we have already talked about. What I hope we do a better job of though is to listen to what is said and to do that continually over the next two days. What do we want to listen to and what do we want to listen for? We want to hear new ideas. We want to hear different thoughts from different people, not only transportation professionals, but environmental professionals as well, and we want to see that there are, indeed, different thoughts and different approaches to reach the same end. To find the right course of action it is going to take all of us working together and listening to each other, and that means swallowing some difficult pills at times. Some large, uncoated, rough-around-the-edge pills that do not go down very easily, but if we do not do that and do it well we won't be doing anything together.

Now, I am not asking everybody to leave here hugging each other and exchanging Christmas cards. I am also not asking us to steer clear of heated debate, not at all. I really expect the conversation over the next two days to be difficult at times, to induce some angry rebuttals or responses, but the more difficult our discussion is and the better we listen, the greater chance together we have of doing our job, and that is to try to use the technologies that are available today to make our world, the world we live in, the world we want our children to live in a little better than it is today, a little greener, a little healthier and to do that we cannot ignore transportation issues any more than we can ignore issues such as clean air.

"How can we listen over the next two days?" and 'Where is that opportunity really going to lie?" There are lots of things on the program, but there are two very important times during the next two days when you can clean out your ears and pay attention, and that is during the breakout sessions. When you participate in those breakout groups listen, lay your ideas on the table and realize that working together we can get a little further down the road and maybe come to a time when everybody knows that we are going to be talking about some different things and getting more focused on the solutions of how intelligent transportation systems are going to play a role and the right role in moving us forward as we try to develop and get ready for the next century.

DR HORAN: Thank you, Phil. As you can tell, we are past our warm-up now, and we need to get into some of the issues that have been raised in our opening remarks. "What is the vision for ITS vis-a-vis transportation in the communities that they are in?" "What kind of programs can be successful or not?" Let us move forward to our first plenary session.

POLICY VISIONS ON NEW TECHNOLOGIES

Moderator: Thomas Deen Executive Director, Transportation Research Board

MR. DEEN: I am Tom Deen, Director of TRB, and the moderator for this first session. The conference organizers in their wisdom wanted to give us a chance at the early part of the conference to stretch our minds and thoughts and everything else to try to get our arms around this subject in its broadest; to get our visions of ITS, our society and the technology and how the pieces weave together into the discussion. It would appear from the papers that I looked over yesterday the issue of how broad we should be considering ITS is itself an issue, with some proposing to look at it far more broadly than we do now. Others argue that we must put some boundaries on it or else we will fall into the planner's dilemma where everything affects everything else, and we end up not being able to deal with it.

We have to recognize that ITS is intrinsically a networking kind of operation. It connects the roads and the drivers, travelers with information, truck operators with regulators, transit passengers with buses, toller with tollees, and the list goes on and on. Many of you have heard me say before that ITS is a mega project that has many similarities with earlier efforts to build transcontinental railroads, the interstate highway system, the Panama Canal and other great projects where we pushed technology to the limits. One cannot be sure of success. It is high risk. The potential benefits are enormous, and the impacts of failure are btg as well. Yet as has already been said here, ITS is a reality. ITS is happening even as we speak. Our job, in part, is to try to mitigate the adverse impacts as much as possible.

ITS is going to have far-reaching consequences. We start off with consensus at least on some points. I read one paper yesterday that said that ITS is an amplifier, that whatever is good about our transportation system is even better with ITS, and the things that worry us are going to worry us even more. For example, if we have a high level of throughput now, we are going to have even more throughput with ITS. If we have got safety now, we will have even more safety.

You can argue that we have two groups in America today: environmentalists and mobility advocates, and that the difference between them is that they desire different outcomes. Mobility advocates want additional throughput and the improved mobility and economic development and other attributes that flow from that, while environmentalists want reduced emissions, less noise better communities, and the various attributes that flow from that. However, I think this is a gross oversimplification. I have rarely met a mobility advocate that didn't have some concern for environmental consequences, and I have not met any environmentalists who would argue that mobility and accessibility to the riches that our society has to offer aren't important attributes.

So, there must be some other things that separate us and underlie our differences. One of them is how we see technology itself. Many would see ITS as simply another technology arriving on the horizon that has the potential for running amuck. Such folks see much of the technology we currently have as already having run amuck. Nuclear weapons were the first big blast off in that direction a half century ago and much of the technology that has appeared since confirm their concerns, including nuclear power, the disposal of nuclear waste, the biotech revolution with genetically altered foods, medicines, animals, and maybe even genetically altered humans, pesticide problems, waste disposal problems, traffic fatalities themselves. None of these problems would exist if it weren't for technology. So, it is not hard to find support in contemporary society for the notion that new technology is something that you have got to approach very carefully.

On the other hand, there is another group who see technology as intrinsically two steps up and one step back and then two steps up and one step back, with gradual overall progress, accepting that there will be unintended consequences which will have to be dealt with through regulation or additional technology. There is lots of historical support for such a view. Steamboats, for example, in the early 1800's, provided great increases in mobility and

economic benefits, but with it came a rash of steamboat boiler explosions, first killing tens and then scores and then hundreds of people and requiring the development of standards and the first federal regulations on transportation safety. Then in the later 1800's came the railroads with thousands of new bridges. The collapse of those bridges killed first tens and then hundreds of people and required new standards and regulation of bridge construction. Automobiles then arrived along with fatal crashes. The rate of accidents was simply enormous, and we had to develop standards and regulations and additional technology to deal with them. Plenty of people got killed even before there were automobiles in transportation, and my great-grandfather died falling off a horse.

Without making too much of it, I think this underlying notion about technology could cause some of our differences here, and it may be useful to recognize it at the outset.

We also need to consider whether our differences are related to how we see other problems in our society. For example, We could agree we have plenty of distress in our cities. Some see transport as a major factor and transport policy as having been at fault in causing many of these problems.

Others see crime and drugs, education, race relations, unwanted population growth, manufacturing technology and information technology as the major factors in urban distress, and believe that trying to cure these problems by transportation policy is an exercise in futility. So, again, it is not necessarily the differences in outcomes that we desire but rather how we see the nature of the problems. We also differ on what may be possible. I think many would agree that congestion pricing may be a reasonable approach but differ on whether and how soon we might be able to put it into effect and perhaps believe that if we rely too heavily on something that is politically unacceptable we may risk losing it all. Others say that if you do not try, how can you know it is unacceptable?

We may also differ on the role of the Federal government. After years of seeing federal programs influence local decision making through their funding streams, now with ISTEA we have transferred some power to MPO's and local decision making. Is this the environment then to come in with single purpose technologies from the Feds that directs transportation policy at local levels?

Finally, we might be able to communicate better if mobility and environmental advocates could accept that each have a point of view that maybe has some value in the VMT debate. Environmentalists seem to hate trip making and see VMT as an unmitigated evil, and appear unwilling to acknowledge that it does provide the access to many of the good things that our rich society provides, whether it is jobs and cheaper retail goods, recreation, education, access to friends and family, health care, culture, virtually everything that we value. More mobility provides more of it, and most people think this is good and are loath to give it up.

Alternatively, mobility advocates seem equally unwilling to acknowledge that there may have to be some limits to these good things. ITS seems to bring this issue into focus because if, in fact, we can get 100 miles per hour and 200 percent increase in throughput through advanced highway systems, this could cause enormous problems that may be totally unsolvable. What now passes for urban areas might disappear altogether with lots more use of energy, lots more noise, lots more emissions (even green cars may have problems in such an environment) and lots more strain on feeder streets and more resources for transportation and on and on. To face those problems early on is something that probably all sides need to acknowledge which is why we are here today.

Now, let me stop. We have a great panel to talk about these and other issues this morning, and the first is Joe Canny who is well known, I think to probably everyone here in the audience. Joe began his career in local government before he came to the U.S. Department of Transportation where he is now Deputy Assistant Secretary for Transportation Policy, and where he deals with many of the problems we are concerned with today, including environmental programs, economic deregulation, safety issues and general oversight of surface transportation policy.

FEDERAL PERSPECTIVE

Joseph Canny Deputy Assistant Secretary for Transportation Policy, USDOT

MR. CANNY: I started out feeling very ambivalent. I thought I was going to continue in the non-substantive vein that Dave Burwell led off with, but then Tom announced that this was a substantive panel, and so, I am not sure where to begin.

MR. DEEN: You can be non-substantive.

MR. CANNY: Okay, that is easy. I first became interested in high technology highway systems as a result of reading some reports about the success of the traffic management schemes that had been adopted in conjunction with the Los Angeles Olympics in 1984. It appeared that those systems -- the traffic management schemes -- had really significant effects in reducing congestion, improving throughput and generally solving traffic problems that had threatened to be a hindrance to the Olympics. From there, I began to think about how broadly those technologies might be applied. I began to learn about the full range of information technologies that could be applied in the transportation area and realized that there is terrific potential in areas, such as route guidance systems, traffic detection systems, radar braking -- a whole range of technologies that go well beyond simple traffic management.

As I became more familiar with ITS, or ITS as we are now calling it, I had two concerns. First, what is the role of the federal government. Tom touched on that in some respects. The ITS technologies are interesting and potentially useful, but the federal government doesn't necessarily invest in new technologies just because they are interesting. We need some system of deciding which ones would have a major impact on improving the range of tools and options available to society and available to policy makers. Many, but not all, of the products and services in the ITS program have important uses for the implementation of our transportation and environmental policies, and it is those that we in the federal government need to focus on.

Second, I was concerned about maintaining a proper perspective. What results can we realistically expect from ITS technologies and services. We must be careful neither to oversell nor undersell the product. Sometimes it has seemed to me that ITS has been seriously oversold. It is portrayed as something of a cure-all for everything from lung cancer to international competitiveness. I think that is a serious mistake. Rather it must be regarded as a set of technologies that can bring incremental improvements in a number of areas, and those incremental improvements together can have major impacts on the efficiency and effectiveness of our transportation systems. There is a real problem if the system is being oversold. That problem manifests itself, for example, in the temptation of some congressmen to try to lump their pet demonstration projects under the heading of ITS. These are sometimes projects of rather dubious merit, and if they get linked to ITS or if ITS, is being portrayed as producing results which really cannot be delivered, there is a potential to quickly undermine the credibility and effectiveness of the whole program.

In establishing ITS priorities and in deciding which user services DOT should help to develop and implement, the ITS community needs to be aware of what is going on in other policy areas, including environmental initiatives. Similarly, in developing environmental policy we need to take into account the highway and information technologies that are already available or will soon become available to help implement environmental objectives.

I will very briefly identify four major initiatives that the Department of Transportation has under way or is participating in that relate to the environmental impacts of ITS. First are the new planning requirements which Tom Deen alluded to. Those requirements will put much heavier burdens on states and metropolitan planning organizations to do their transportation planning in a way that goes well beyond the traditional highway and traffic considerations. The planning must take into account a wide range of social, economic and intermodal considerations, a very broad range of approaches, such as Dave Burwell identified, including thinking about the livability of our communities.

That is going to be a real challenge to transportation planners around the country, and it is going to be something where they are going to have to use every available tool. The ITS tools may be of help to them in that process.

The second area where we are concentrating a lot of attention is in the area of transportation an air quality. Both the Clean Air Act Amendments in 1990, and the ISTEA require that transportation and air quality objectives be made more compatible. Through the CMAQ (congestion mitigation and air quality) program, some \$6 billion was authorized for that purpose. We have tried to assure that a wide range of innovative approaches can be used in the states and metropolitan areas to apply the transportation funds to support air quality objectives. Again, ITS technologies may be an important tool that states, and metropolitan area, transportation planners and environmental planners can utilize.

The third area that we are working in is the area of global climate change. As most of you know, President Clinton released a Climate Change Action Plan last fall. The objective of the plan is, in the short term, to return emissions levels of greenhouse gases back to the level that they were in 1990, and over the longer term to make greater reductions. In that action plan, there was very little mention of transportation. Some of the federal agencies, notably the Departments of Energy and the Environmental Protection Agency, were concerned that transportation was not being asked to bear its fair share of the required reductions in green house gas emissions. As a result, the plan calls for an effort over the next year or so to try to identify a set of policies and technologies that can be utilized by the year 2005 and perhaps beyond, to make significant reductions in the greenhouse gas emissions from personal transportation.

A Federal Advisory Committee is in the process of being formed to address the problem. We hope that it can be finalized over the next couple of weeks. That committee, which would represent global climate change stakeholders from a broad cross section of transportation and environmental interests, will be charged with trying to come up with a politically feasible set of initiatives in the transportation area to reduce greenhouse gas emissions. That, too, will be an area where ITS technologies can play an important role.

Finally, the Department is an active participant in what is now called the Partnership for a New Generation of Motor Vehicles: it was previously known the Clean Car Initiative. Under the Clean Car Initiative the Administration is trying to collect its various transportation, oriented research programs to merge with the research programs of the auto industry. The program is to come up with prototypes for a new generation of motor vehicles, by roughly 2003, a generation of vehicles that would have three times the level of fuel economy that current vehicles achieve.

We are looking for a prototype vehicle comparable to the Ford Taurus, that currently gets about 24 miles to the gallon that would have comparable size, comparable performance, comparable or better safety features and will get 72 miles to the gallon. This is a significant challenge, and again, ITS technologies -- information systems, for example -- will be an important supplement to the hard technology efforts in that program.

I would like to close with a couple of common themes that I might mention and some final suggestions. ITS has on several occasions been compared to traditional improvements in transportation system capacity. Even supporters of the ITS program have said that what ITS will do is to take the place of an extra lane on an interstate. People who are concerned about the environment have said that if that is the case it needs to meet the new strictures against additional environment-degrading capacity. In reality, some ITS services and products may, indeed, be substitutes for additional concrete and asphalt and those technologies may, indeed, have to jump over some of the environmental hurdles that are being imposed on new highway capacity in general.

A lot of ITS, however, is very much unlike a new lane on the interstate. A new lane or three lanes or 20 lanes will still present the highway user and the transportation planner with what might be called "dumb capacity." People do not receive the correct signals on what their use of the road does to other users and to the environment. To the extent that the new information technologies can identify and present highway users with better and more timely information, the new products and services are fundamentally different in that they can present information to individuals and transportation planners on the economic and environmental consequences of their actions. That additional information can be critical to obtaining the environmental benefits from our transportation system and from

ITS technologies.

I would like to close with five, what I started to think of as conclusions. But recognizing that we are at the start of the conference rather than the end, I guess they should be characterized as hypotheses, that people can think about and challenge during the remainder of the session. These conclusions or hypotheses would be as follows:

First, we need to move ahead with development of ITS technologies. As Dave Burwell said, the train has left the station and is moving. Public sector interests and investment should focus on those technologies that offer promise of concrete benefits in areas such as congestion relief, environment and safety.

Second, we must be careful not to exaggerate the potential benefits, environmental or otherwise, of ITS. That will quickly undermine the program.

Third, we must recognize that ITS technologies are not universally beneficial from an environmental perspective. Those technologies that have adverse environmental consequences, whatever their other benefits might be, will have to be scrutinized very carefully before they receive public support.

Fourth, the challenge of meeting clean air and global climate objectives is enormous. A wide variety of technical and policy approaches will be needed in both areas. ITS technologies can contribute, and those contributing technologies need to be developed and implemented with a sense of real urgency.

Fifth, ultimately the effective use of ITS will require institutional and political commitments. States and local governments, in particular. will have to make some tough decisions on using technologies to support policies such as transportation demand management, congestion pricing, transit priorities, etc. Those decisions will be critical to the successful application of ITS to environmental problems, and to the final judgments as to whether ITS is or is not environmentally beneficial. It is not too early for us to begin thinking about building support for the necessary political and institutional and financial commitments at the state and local levels.

I wish you success in the remaining two days of the conference. I hope these few thoughts are helpful. Thanks very much.

Our next panelist is Andrew Otis. Andrew is the Special Assistant to David Gardner, the Assistant Administrator for Policy, Planning and Evaluation at EPA. Andrew works on a variety of issues, including global climate change, transportation and air pollution policy. Earlier he worked in the Office of Policy Analysis where he evaluated hazardous air pollutants policy. He has a master's in public and environmental affairs and a law degree from Indiana University.

Andrew Otis Environmental Protection Agency

MR. OTIS: Good morning. On behalf of EPA as a cosponsor of this event, I want to thank you all for coming. All of the agencies and institutions and groups that are sponsoring this conference have already contributed a great deal to the thinking on ITS and how it may help fulfill the many expectations we have for transportation. I think the papers presented here and the discussion they generate will be further contributions to that thinking.

When EPA Administrator Carol Browner speaks, she often articulates her vision in terms of the future for her son, Zach I think we would all be pleased with a future where our children move quickly and conveniently from place to place in unprecedented safety. However, that vision would not be complete without clean air, a stable global climate system, viable ecosystems and attractive and safe communities in which to live.

We must keep this vision in the front of our minds as we use our amazing information management technology to develop intelligent transportation systems. These intelligent transportation systems must be designed ultimately to help us achieve what we hope to achieve with all environmental technologies to help satisfy the demand for a growing economy and a healthy environment.

Only by doing this will we build a sustainable transportation system. We have already seen many environmental and economic benefits from applying advanced information technology to transportation. Shipper's clearinghouses are helping shippers and truckers find each other, reducing empty back hauls. Global positioning systems help railroads improve their service and carry more freight on their efficient network. Sophisticated cameras line urban highways and help alert officials and drivers to developing congestion. Smart cars speed people through toll lanes, eliminating congestion while making it possible to begin treating roads like the utilities that they are. These few examples focus on ITS's ability to improve efficiency and eventually lead to environmental benefits. Efficiency leads to lower emissions, less need for roads, less road runoff, less noise, and much more.

Some ITS applications even benefit the environment without efficiency improvements. Remote sensing of emissions, for example. EPA is particularly excited about the opportunity for ITS to improve the efficiency of an alternative to single occupancy vehicles; from high technology ride finders to dial-a-ride paratransit, and all the way up to smart lamp posts that know when the bus is coming. These not only provide people with more transportation choices, it may also help increase the public s return on its transit investment. It could also bring service levels to the poor that are now available only to the rich.

However, ITS also presents areas of concern. If ITS is only used to increase vehicle throughput, and its advanced information services are available only to the better off, then we will have missed an opportunity. We will also end up harming our health and the environment because that increased throughput, all else being equal, leads to more driving and more emissions. By increasing throughput we will also have made the auto yet more attractive relative to other forms of transport and failed to invest more money in alternatives to roads. I think we need to be careful and expect of technology only what it can really deliver. ITS may be able to alert us to congestion, but if there are no alternative uncongested routes it will do us little good. Advanced information systems applied to transportation cannot by themselves solve our transportation problems of economic inefficiency, environmental and health damage and unequal access.

EPA's position then is that ITS, as with all environmental technology, is a tool to enhance economic growth and protect the environment. The opportunities to move our transportation system towards sustainability are great, and we must take advantage of them. We look forward to this conference producing guidance on the actual potential of many of these tools, how the federal government and society can best use these tools and which tools are worth pursuing and which are not. Again, I want to thank you all for coming and for all of your hard work.

Our next speaker is Hank Dittmar, the Executive Director of the Surface Transportation Policy Project. Hank is a young man who is making lots of waves these days. He comes from both sides of the aisle in the discussions that we will be having over the next couple of days. As the Executive Director of STPP, he is the director of a coalition of more than 100 groups that seek to ensure that transportation policy and investments are directed towards the conservation of energy and protection of the environment and aesthetic quality, and the other goals of that type, while at the same time strengthening the economy.

Prior to his recent acceptance of this position, Hank had 15 years' experience in transportation policy and operations, most recently as manager of legislation and finance for the Metropolitan Transportation Commission in Oakland, California, where he was responsible for both legislative and policy development activities and the programming of the region's \$11 billion transportation budget.

PROCESS AND PARTNERSHIP

Hank Dittmar Director, Surface Transportation Policy Project

MR. DITTMAR: I guess you are wondering how I can be both a democrat and a republican if I am from both sides of the aisle, but I am not going to tell you which I am.

As you heard from David Burwell, STPP is fully vested in the process of working with groups like ITS AMERICA to try to make sure that the application of intelligent transportation systems is in fact something that rebounds to the benefit of society and the environment. We are here today to try to work with you to make this thing work, but we come from the perspective that there are some profound problems with the way that we approach technological innovation in our society and perhaps particularly in transportation. I would like to start with a quote from Gregory Bateson who is one of my favorite philosophers and psychologists. He invented what is called the double bind theory of schizophrenia and went from that to being one of forerunners of systems analysis and cybernetics.

Gregory Bateson basically says, "All ad hoc measures leave uncorrected the deeper causes of the trouble, and worse, usually permit those causes to grow stronger and become compounded. In medicine, to relieve the symptoms without curing the disease is wise and sufficient if and only if either the disease is surely terminal or will cure itself." I think this really goes a long way toward telling us how we need to be thinking about applying technology to transportation systems, and it is probably not enough to say that we are going to apply this technology to reduce air pollution or to improve congestion relief. Those are, in fact, not the questions we need to be asking ourselves. The questions we need to be asking ourselves are how do we recast ITS AMERICA's goals and its program plan for ITS in order to meet the goals and objectives of a larger society. To do so we need to think about what those goals and objectives are, and we need to think about making our transportation system a healthy system from the standpoint of its interactions within itself and its interactions with the larger environment and the larger society.

I would submit that at this point the program plan for ITS AMERICA and, in fact, the publications from U.S. DOT do not particularly cast IVHS, or ITS as it is now coming to be called, in that larger social and environmental context. Nor do they orient themselves toward making the transportation system a healthy system from the standpoint of its own interactions. I think that is the true promise of ITS technologies, and we need to reorient our basic approach to the problem in order to begin to do that.

Let me start by posing for you some different kinds of goals. The goals that we talk about now are really goals about the transport system and the goals about the industry that we hope to develop with ITS and ITS technology. I would suggest that the goals that we need to have are two kinds. They are goals that relate to society and community and the environment, and they are goals that relate to retrofitting our transportation system.

Let me pose four broad social and environmental goals. First, ITS technologies should be conserving of resources, and when I speak of natural resources, I speak not just of fossil fuels and not just of limited mineral resources, but, also, of agricultural land, open space, historical structures and neighborhoods. We need to have a principal goal of saying that our transportation system ought be conservative in its approach to society and the environment.

Secondly, I would suggest that ITS technologies need to be supportive of local and regional economies. We tend to talk too much in addition to supporting the nation's economic competitiveness. We tend to talk almost entirely now about competitiveness of the nation abroad -- but the foundation of that national competitiveness is in integrated metropolitan and rural regions. So, ITS technologies need to be focused upon making those metropolitan and rural regions competitive and healthy, and that involves, for example, strategically investing in ITS to make the

freight system work better. That means enabling metropolitan transportation agencies, MPO's to develop a metropolitan transportation system that interacts with all of the modes and that knits a region together in a sense so that people can have access to jobs and so that people can have access to goods.

The third goal, I think, is that we need to stop being mobility advocates and recognize that mobility is but one way to achieve a larger social goal. That larger social goal is accessibility: accessibility to jobs, accessibility to opportunity, accessibility to education, to housing and to the enjoyment of life. Those are the guaranties that are provided in the Constitution, not the guaranty of freedom of travel at unrestricted speeds. This broader concept of accessibility recognizes that one way to provide access to these opportunities is mobility, but that goal can, also, be served by enabling someone to avoid a trip. That goal can also be served by recognizing that accessibility is something that needs to be provided to all, and that we may not be able to trust the market to solve all of our problems and a reliance on technology may result in pricing many aspects of our society out of the ability touse that technology.

A fourth goal would be that we need to use ITS to build safe and healthy communities. If you ask people what they want or what they are concerned about, they are concerned about safety. They are concerned about security. They are concerned about community health and education, and I think that thinking in those broad terms about what ITS is supposed to do would move toward implementing technologies that build communities and neighborhoods rather than disrupt them.

The second broad set of goals that I think we need to approach for ITS is to retrofit our transportation system so that it is a healthy contributor to broader society, and I would submit that it is not. I would submit that the earthquake in Los Angeles proved that we lack sufficient flexibility, that we lack information systems to allow us to respond to crisis and that whenever we have a sporting event in a major city we have to go to unprecedented means in order to keep the system from breaking down.

So, I would submit three goals here for ITS. First, Its main objective with respect to transportation should be the following: to make an informed and aware transportation system. To provide information to users and to system operators to allow that system to operate in an optimal fashion, not a maximal fashion but an optimal fashion in order to achieve a broad set of social goals.

Second, ITS technologies should be integrative. They should be focused on bringing the different system components together, the information component, the different modes, the freight and the passenger components. We should be looking to tie things together, and that is a real promise of ITS.

Third, we need to reinstate flexibility and redundancy into our system. Basic systems analysis and systems theory will tell you that a system which does not have alternate pathways is likely to go out of control and if it goes out of control the only thing you can do is put governors on it to try to damp its speed.

I would submit that we do not need governors. What we need is alternate pathways. We need redundancy. We need flexibility. When we had an earthquake in the Bay Area, the Bay Bridge went down, but we had the BART system, and we were able to move people to work on the BART system under the bridge, and so those are the kinds of things we need to use ITS to do, and if information is an alternate to a trip then that is an important part of it as well.

Thinking about those broad goals I guess I would say that we do not do that yet with ITS and ITS AMERICA and DOT's plans. There is, at this point, a fundamental disconnect between the approach to the development of technology and the analysis and review of social, environmental and political issues. As I took several hours to reread the ITS National Program Plan, I noted that there was a package of user services in that plan that applied to basic technological features, and they were oriented to users, but the discussion in terms of social and economic and environmental issues was segregated from the development of that technology. We need to have an integrated approach because if we develop the standards for the technology and then seek to mitigate the impacts of that technology later, we are going to have a train wreck on our hands, as the Washington Post recently editorialized, comparing the electronic and asphalt highways is useful but mostly as a cautionary tale. "Building the new

information infrastructure will not entail the degree of immediate physical disruption caused by the interstate highway system but sweeping geographic relocations and accompanying social transformation seem probable, and the risk of inequity in contriving and distributing electronic services or conversely imposing them where they are not wanted is clear." We need to think from the outset about the impact, and we need to have goals which are related to what we want society to do. So, we need a bigger picture.

I would close by saying a few things about some self-imposed limitations that we need to get rid of. One, environment is more than air quality, and improving air quality is not necessarily improving environment. There are interconnections amongst various aspects of the environment. Let me cite a few of the things that we need to think about, water quality, open space, the preservation of agricultural land, neighborhood cohesion, pedestrian and bicycle safety, the location of facilities and environmental and economic justice.

For example, if we are thinking about doing ramp metering on the metropolitan transportation system, we have to think about the whole system. If we only meter the close-in ramps near to the downtown, what we are providing is an access advantage for people who live in the suburbs. We are providing an access disadvantage for people who live in the inner city neighborhoods, and they are likely to be poor.

We need to think about system impacts in a broad sense. Public involvement is a critical aspect, and it is more than just going around the country and having meetings. It is recasting your system. It is more than developing a market for your projects. It is recasting your services in terms of what people want, and I would suggest that we need to take those user technological bundles that we provide like advanced public transportation systems or commercial vehicle operations and recast them in terms of the benefits that they will provide to citizens and to decision makers. That will probably help sell the product but it will also, make clear what we expect to get out of it.

In conclusion, we are positive about having this conference. I was criticized by some for signing up as a cosponsor of this conference because by doing so, we were embracing ITS and ITS technologies. We are positive, and I am committed to using the resources of my organization to work with Jim Costantino and his partners to make this technology work for society and the environment, but we do so with a healthy skepticism.

I want to end by quoting Jerry Mander who wrote a recent book about technology called In the Absence of the Sacred. He said that "We must eschew the idea that technology is neutral or value free. Every technology has inherent and identifiable social, political and environmental consequences. Negative attributes are slower to emerge. In thinking about technology within the present climate of technological worship, emphasize the negative. This brings balance."

MR. DEEN: Let us turn now to Jim Costantino, the Executive Director of ITS AMERICA Intelligent Transportations Systems. America. Jim is an individual I have known for many years, back since the days when he was director of the Volpe Center in Cambridge, Massachusetts. Before he took this current job and after his Massachusetts experience, he was professor of transportation and engineering at George Mason University and Associate Dean and Professor of Engineering at George Washington University.

I think most everyone would acknowledge that Jim has done a fantastic job in managing the buildup very quickly of an organization, ITS AMERICA to be one of the really important transportation organizations in our society, and we are pleased to have Jim with us today.

James Costantino Executive Director, ITS AMERICA

DR. COSTANTINO: This, as you all know, is a very auspicious day. Fifty years ago the Allies invaded Normandy, and I hope that a year from now we can look back on this particular meeting that we are also having as being an auspicious day. I think as I look around the room and see the array of talent that we have here in transportation and in the environment, if anybody ever tried to write a book on transportation and the environment, and they didn't mention the names of some of the people here, it would sort of be like trying to write a history of the Boston Red Sox without ever mentioning Ted Williams.

A few years back in the sixties we only had a few things to think about when we planned transportation: energy, environment, safety and land use. And now, we have a whole plethora of things that transportation planners have to think about, including aging drivers, whether or not the military-industrial complex, the National Labs are used properly and whether their employees have work to do, changing travel patterns and fiscal pressures on local governments, but most of all, of course, is ITS. The ISTEA Act described what the ITS program's goals would be with reference to advancing the highway system without adding additional fiscal capacity, and the Clean Air Act as mentioned, reducing social, economic and environmental consequences. We are talking about developing and promoting a U.S. ITS industry. We talk again about using the National Labs building a technological base and facilitating technical transfer.

That, again. is quite a chore for people who heretofore were just doing business in transportation, but there are some immediate problems that we are here to talk about today at this particular meeting. Travel is growing, whether we like it or not. Congestion is worsening. Delays are cutting productivity, and environmental concerns are increasing. Hence this particular meeting.

So, what is happening? We are taking some new directions; some new underlying thinking is taking place in transportation. People are beginning to think now of transportation systems. I heard a conversation from the Secretary of Transportation's speech at the U.S. National Chamber of Commerce in which he emphasized the need for a unified national transportation system, and that is really great because that is what we ought to be thinking about.

We are talking more about accessibility and not just about mobility. As a matter of fact, in the ITS program, accessibility is given increasing emphasis. We have different players now in surface transportation than we used to have before, and if we deal with transportation as if you are dealing with the same group of players, you will really be missing the boat. More than 50 percent of the people that are engaged in ITS today, who are engaged in putting information technology in transportation, are not the traditional surface transportation people. They are people who may have never been in that business before. Finally, there is a bunch of demographic changes, many of which I am certain that you already know about.

ITS AMERICA was formed as being a multimodal operation in 1990. ISTEA came along in 1991. There is a DOT Intermodal Office that was set up in response to that ISTEA legislation. There is currently a Borski bill which is talking about putting together a national transportation system. I am not here pushing the Borski bill, but the point is that he is looking toward transportation as a system. And finally, if you take a look at the user services of the program plan in 1994, you will see that much of what is in there deals with transportation as a system. There are some accessibility related committees and task forces that are working on ITS at the present time. I understand some other speakers will be addressing this issue, so I won't get deeply involved in it. But accessibility is one of the key goals of ITS, or ITS or whatever you call it.

You should know that ITS AMERICA as an organization is not just an organization of private businesses. Forty-nine percent of the member organizations are public organizations, and those organizations in the main are made up of state and local organizations. There are a few associations, public interest groups and so forth, with 31 of the states accounting for 90 percent of all of the activity which is projected in ITS are members of the ITS AMERICA

organization. There are over 500 organizational members at the present time and 5 percent are private sector firms. But more to the point is that traditional firms only account at the present time for about 56 percent of the membership in ITS. Most of the organizational membership are companies that were not in transportation four or five years ago. They are in the information technology business. They are in the space business. They are in the defense business, and so forth. Although there are a lot of the traditional companies there, many of them are not. The National Labs are now deeply involved in ITS business rather the space business. They were not there before, and companies like Northrop, organizations like Jet Propulsion Laboratories and so forth are now part of the whole ITS program that were not traditional transportation firms.

There are some commuting trends over the years that more people are using private vehicles to commute, and the number of people who are using public transit is decreasing as a share of the total. The number of people who are walking to work is decreasing. The number of people who are working at home is increasing slightly. So, accessibility seems to be making some gain there, but private vehicle people are still increasing.

According to a book by James Trefli, "A Scientist in the City," suburb-to-suburb commuters nationwide are roughly 37 percent of the total; city to city, 31 percent; suburb to city 19 percent; city and suburb to neighboring metropolitan areas is 7 percent.

So, I am sure this confirms what you have already known and that is that the large number of people are not commuting from the suburbs to the center city. They are commuting from suburb to suburb, and they are commuting from metropolitan center cities to the suburbs. As a percent of all trips by purpose, to or from work is about 20 percent, and other family and personal business is about 22 percent. So, the number of people who are using their vehicle for other than going to work has been increasing a great deal. Social and recreational, for example, is almost 15 percent of highway use.

So, with these facts and figures, how can ITS help? In a recent paper that was delivered by Berman and Sinclair from FHWA at an ITE conference, they listed five ways that ITS could help. They talked about how it could help in limiting, organizing, and restricting the HOV lanes. They talked about congestion and roadway pricing which seems to be taking hold in some places around the world, especially in countries like Singapore. They also mention parking management and control, air pollution and emission detection, traffic management centers in dealing with modal shifts in response to varying conditions in the metropolitan community. Some options they did not mention were telecommuting and demand management, and improved accessibility to public transit.

Of all the user services that affect public transit directly or indirectly, out of the 28 user services, 20 of them are directly or indirectly related to public transportation or accessibility. But there are still many challenges to intelligent transportation systems deployment. Of course, one of these is deployment funding. There are still a lot of tests that are going on around the country and a great many corridor improvements and so forth, but we still do not see any line items that say, "Transportation, ITS Deployment."

We do need uniform national standards, and there is a great deal of work that is going on in this area. I should say probably not just national standards but international standards. We need a lot of local involvement that we are not getting at the present time. There needs to be more outreach to state and local governments but mostly to local governments and local organizations like MPO's. Larry Dahms, the Chairman of our Board, will tell you more about that later. We need new government/private sector partnerships. We have put together under Craig Roberts and Jack Fearnsides of our staff and of our board a program of trying to develop and come up with recommendations for public-private partnerships.

We need much more user friendly public transit. There is no sense forcing the public into dirty transit cars that do not go where the public wants them to go and do not come on time. We ought to know more about that, and we can learn a lot from our foreign neighbors as to how that is done. We need definitely other federal government involvement, federal agency involvement, in addition to DOT.

The Department of Energy should be involved in a big way, and it is not. The Environmental Protection Agency, although it is here and participating with us today, is not involved in some of the activities that go on. The Department of Commerce is not involved. The Department of State is not involved. This has to be an agency-to-agency kind of operation, and I do not think that ITS AMERICA or private industry can do this by itself. but we need more federal agency involvement than what we have now.

I like to think that we have a lot of tools in ITS, but we have a lot of problems, too. It is sort of like a puzzle. What we are trying to do is put all these pieces together. I think that ITS can help.

MR. DEEN: Our last panelist is a gentleman whose name I have heard for many years, and is well known in the transportation field. Mr. Elmer Johnson who is a partner in the national law firm of Kirkland and Ellis, and I was pleased to have the opportunity this morning to meet him for the first time in person. Mr. Johnson was general counsel and held responsible positions in General Motors Corporation, on the Executive Committee and on the operating public affairs staff, Executive Vice President of the firm and a director of the company and served as a member of the Executive and Finance Committees of the board up until 1988.

Most recently, Elmer Johnson has presided over development of a report prepared through the American Academy of Arts and Sciences, of a Fellow, entitled *Avoiding the Collision of Cities and Cars: Urban Transportation for the 21st Century.* The report is based on the deliberations of a cross-disciplinary panel of experts assembled to work on that problem. So, we are delighted to have Elmer Johnson with us this morning.

PRIVATE SECTOR PERSPECTIVE

Elmer Johnson Partner, Kirkland and Ellis

MR. JOHNSON: I was greatly relieved when Hank Dittmar got up and began to read philosophy and psychology because it made me realize that I was not after all the only liberal arts major here in this group today. Now, Tom mentioned the study that was completed last September, and some of those interdisciplinary experts are in this group today. I see my friend Dan Sperling over here, and Dave Burwell whom you heard from earlier.

We had about 30 experts in all. What we basically concluded in that report is that there is no single magic bullet. There may be 25 little bullet us that if properly employed in a complementary fashion can add up to a magic bullet. I will take David Burwell's challenge seriously today and build on the principles that Hank Dittmar laid out and try to flesh out the kind of vision I think does put all these bullet us together and gives you something to think about as you go ahead with the rest of this conference.

Two themes emerged during the course of our project. One was the conflict between the purposes of cities and the demands of the private motor vehicle. The other was the tension between the equity of urban life and the privatization of mobility. At the outset of our final, week-long seminar in Aspen, using Thomas More's Utopia as our guide, some of us took individual turns at delineating a vision of an urban transportation system 20 or 30 years hence and imagining in a retrospective sense how that vision might have been achieved. The idea was that before we developed our recommendations we should take account of these two themes and do a little dreaming about the kinds of cities and transportation systems toward which we should aspire. For me it helped to focus on a particular city, and I have since focused more on that city, namely, metropolitan Chicago where I live.

Here then are the main features of metropolitan Chicago's transportation system that I envision by the year 2020. First, it has *mobility without externalities*. The environmental, energy and congestion problems once posed by the motor vehicle are no longer significant in the Chicago region. Several factors account for this extraordinary achievement. First, more than half of all vehicle travel in the region is by small electric cars and by larger natural gas fueled cars, vans, buses and trucks. Second, diesel and gasoline fuels are far cleaner than they were in 1994, and they bum much more cleanly, thanks to advances in engine technology. Third, per capita vehicle trips are down 40 percent from the 1994 level, partly because of the implementation of the report's pricing strategies, partly because of more compact land use patterns and partly because of telecommuting. Over half of all employed persons now work out of their homes at least one day a week. Computer and communications technologies have greatly reduced mobility needs in other arenas of activity as well: education, shopping, entertainment and the common pursuit of hobbies.

Several elements combined to reduce traffic deaths and serious injuries by half: the sharp reduction in vehicle travel, the now widely accepted social norm of the designated driver, the severe penalties imposed upon intoxicated drivers, the elimination of large trucks from densely populated areas, and the widespread use of dedicated street levels for smaller trucks that are permitted in such areas. and the implementation of technologies that alert drivers to potential collisions.

Second, it has *public transit and intermodalism*. The various forms of public transit now account for the majority of all travel to, from and within Chicago's downtown core. This is due not only to the pricing mechanisms that were introduced early on, but, also, to some ingenious initiatives that have made public transit much speedier than the car in high-density areas. Traffic lights that automatically turn green for approaching buses and trams in preference to private vehicles at intersections and slightly elevated lanes reserved for trams, buses, taxis and emergency vehicles.

Further, private vehicle access to downtown Chicago. except for local residents, is subject to stiff fees that are electronically imposed and collected, and they vary according to time of day. All but a very few commuters opt not to pay these fees. Rather they commute by rail, car or van to the edge of the downtown core where they switch easily to something we are now working on in Chicago. It is called the Circulator. If all goes well, it will be in operation by the year 2000. It is an electric streetcar system. The north-south line will stretch from roughly the Drake Hotel, Oak and Michigan down to the Exposition Centers at 2200 South, and the east-west line will stretch from the railroad and park terminals west of the city all the way over to Navy Pier, and of course, these two lines will connect up, and so. in 2020, as I say, the vast bulk of the population coming downtown will either park on the edge of the downtown core or they will take the rail and switch easily to the Circulator which brings them to or within a very few blocks of their final destination.

It turns out that the Circulator project, more than any other single strategy, built on the city's unique strengths: the beauty of its lake front, its legacy of railways, and the economic and cultural vibrancy of its core. By reinforcing these strengths. the whole region has prospered, and now I get to this point of retrofitting that Hank talked about.

As public transit grew more dominant, thanks to the Circulator, it became feasible to exploit Chicago's legacy as the rail center of the nation by recreating natural neighborhoods around major train stops in both Chicago and the suburbs. These mixed use developments serve not only as social centers, they, also, provide easy links between complementary modes of mobility: park and ride facilities, a few of which contain extensive vehicle service and repair facilities; clubs and agencies that own and maintain rental fleets of vans and recreational vehicles; and rail cars and buses with storage facilities to enable bicyclists to change easily from one mode to another.

The new intermodal system for freight has brought about extraordinary efficiencies in truck transportation, to say nothing of many other benefits arising out of the diminution in truck traffic on streets and highways. Heavy long distance trucks, as well as freight trains arrive at and depart from a few major transfer stations on the urban periphery where their goods are easily transferred by standard container to and from local delivery trucks. The cumulative effect of all these changes is an urban environment that is far more pleasant and safe for pedestrians and bicyclists, to say nothing of the reduction in noise and pollution.

Third, it has *mobility with equity and efficiency*. A basic level of urban mobility is now made available free of charge to persons meeting specified means test. Such a program was facilitated by the use of electronic cards that are debited as used. Low-income users' cards are automatically credited each month, and the cards give access both to public transit and to electronically priced roads and parking facilities. The subsidies are funded with revenues derived from the various pricing measures imposed on private vehicle use on the part of middle and upper income groups.

In the late nineties, several bifurcated planning agencies that have to do with Chicago area transportation, both transit and highways, were merged into one body. The purpose was to integrate and confer on this one body the land use and transportation planning functions as well as the oversight and funding of both highways and transit. At the same time this new agency was empowered to impose a variety of pricing mechanisms to reduce auto congestion and to fund public transit. The annual net revenues derived from parking and road pricing now total over \$1 billion in 1994 dollars. This is based on a recent study in Chicago of the revenue potential of this kind of pricing system. As time went on the regional agencies' functions were expanded to include the power to prohibit exclusionary zoning and to impose other equitable limitations on the zoning powers of the area's many cities and villages.

As a result this regional body is beginning to eradicate the perverse stratifying effects of privatized mobility and the century-long fragmentation of governmental units. Illinois was compelled to make these moves as legislators came to realize that the well-being of the state was tied to the economic vibrancy of this metropolitan region and that the long-term costs of metropolitan and dispersal stratification had seriously weakened the region's ability to compete in global markets.

In hindsight we now know that the old auto-induced patterns of urban geography because they had severely constrained access to education and opportunities for work and acculturation had contributed mightily to the growing inequality of income distribution throughout the eighties and nineties. In 1993, the top-earning quintile of families accounted for 51 percent of total income, and the lowest-earning quintile of families accounted for only 4 percent of total income. Today, in the year 2020, those figures are 40 percent and 10 percent respectively. No one questions that universal access to basic mobility and the related reconfiguration of urban land use patterns have been among the key factors in bringing about a more equitable society.

Finally, it has *quality of metropolitan* life The long-term trend during the 20th century toward low-density sprawl and the conversion of ever-more urban space to vehicular and private use was reversed, and the metropolitan area is now dotted with parks, green belts, village social centers and bicycle and pedestrian rights of way. This move toward greater amounts and kinds of public spaces was accompanied by changing consumer preferences and housing for garden apartments and condominiums, townhouses and detached single family homes on small lots. People are beginning to rediscover the joys of walking and biking between home and church or school or village center or park.

These then are the principal elements of an urban transportation system that I believe is achievable over the next two or three decades. This vision takes into account the limitations posed by the built environment and the constraints imposed by our political, economic and cultural circumstances, but it is also based on possibilities afforded by emerging technologies such as those you are concerned with here, as well as by evolving organizational ideas that will better enable us over time to reshape the urban setting in ways that recognize the claims of justice and the social and aesthetic values that inform the purposes of cities.

The political impediments to the realization of this vision are immense, but they will never be overcome if there is no dream or if that dream is poorly communicated. It is only as we are enabled to visualize a far better future for our children and grandchildren that we may learn to change our ways, and so, I invite you to join in this process that and to revise and improve upon the dream that I have presented. And please do not be afraid to make mistakes along the way. We do learn from our mistakes.

ROUNDTABLE QUESTION AND ANSWER SESSION

MR. DEEN: I want to commend the panelists for being disciplined with respect to their time, and we have, in fact, arrived at the point in the schedule where we can interact with you and interact with each other a little bit. Let us have questions for the panel.

MS. HATHAWAY: My name is Janet Hathaway. I am with the Natural Resources Defense Council, and I am very interested in the vision you presented, Mr. Johnson. I was wondering if panelists, including yourself, could react to the idea or could give some ideas about how ITS technologies could enable local communities and local governments to recognize or to actually measure the costs of the current sprawl development that we are so familiar with in our cities, and basically how is that going to be a part of our ITS architecture? Have people considered that?

MR. DITTMAR: I think I will probably leave it to Mr. Costantino to give the architecture response, but I do think that one of the potentials of the ITS technology is the ability to pay for all modes of transportation with a single card, to be a smart travel card, and we could build into that whatever costs we agree as a society are truly charged off to different modes. You can also use that card as an instrument for dealing with inequities in terms of providing people a basic right to travel. So, I think that clearly is one of the opportunities.

DR. COSTANTINO: I might just take off a bit on something that I had said during my presentation, and that is that we are looking for more participation as we develop our plan, as we continue to develop the strategic plan developed about a year and one-half ago and as that plan will be revisited and updated in about six months. We are very busy right now with the program plan and working through some major items in the system architecture, but the important point, I think to remember is that no one knows just exactly what all of the framework will be for ITS. It is being developed as we speak and so I think the answer to how we deal with problems like those in Chicago and in other cities is to get everybody who has an interest involved. We have tried to make this as easy as possible for them to come and work with us at ITS AMERICA.

MR. JOHNSON: In answer to your question and building on what Hank said, I would be very interested in what ITS technologies can do to improve security on public transit. It seems to me that is a very high priority: the disabling of cards held by people who commit trans-related crimes or who lose their cards, for example. I am sure that is going to be a burgeoning area of interest that could make public transit much safer than it is today.

MS. KANNINEN: I am Barbara Kanninen with Resources for the Future. I would like to comment on what I think has been an implicit assumption underlying all of the discussion so far, and that is that because this conference is titled ITS and the Environment that we should focus on the use of ITS for improving the environment, and I think that is a rather limiting way to look at the overall problem of transportation and the environment. As I understand it, the primary purpose of ITS has been and I think still is improving system efficiency, as was mentioned, I think getting people where they want to go faster than before and to more places is definitely a public benefit. The fact that public transportation imposes very high societal costs, including environmental costs is an overall problem that we also have to address. I think we have to acknowledge that ITS does in general promote more transportation use and so, we need to look at how we can develop policies to target and address the environmental and societal problems. I am not sure that ITS is the answer to that problem. It may be that it is an appropriate way to get the public benefits associated with mobility, but that we need to look at other policies to attack the environmental problem directly such as pricing policies, maybe clean cars, things like that. I am not sure that I am asking a question for the panelists to respond to, but if you have any responses to my comment, I would appreciate it.

MR. DITTMAR: I hope that you heard me agree with you in my speech.

MR. DEEN: I would certainly agree with that. I mean obviously what we are dealing with here is ITS in a larger transportation context, as well as a larger societal context, and for many of the problems that we are considering, ITS is only a piece of it. Here is a question over here.

MS. KONHEIM: I am Carolyn Konheim from Konheim and Ketcham. The question I have is for Mr. Costantino. I heard that ITS AMERICA is thinking about changing its name to ITS. I think it would be helpful to carry that theme throughout this meeting, to call it ITS. Can you tell me whether that is symbolic or a very important change for your organization. I think that would be very helpful because in my dealings with transit agencies in the New York Metropolitan Area I find that they have dismissed this as being something applicable to them in spite of your pointing out that 20 of the 27 services have potential for transit. They just feel the table wasn't set for them, and they haven't even looked at the menu.

DR. COSTANTINO: Let me give you the answer about ITS versus ITS and where we stand with that. Our Coordinating Council recommended to our board of directors that they would look into that name for a whole host of reasons, one, for example, the European Community would prefer that we do not use the name ITS. They use other names there, and as we go into international world congresses and so forth, it would be nice to have a single name that the entire international community agreed on. In any event, we have hired the consulting firmof Booze Allen to conduct a survey, and their report will be made to the next board of directors meeting which is at the end of July. At that time the board of directors will take that under consideration as to whether or not a name change is appropriate.*

I do not put a lot of stock in what the name is per se. Actually two-thirds of public transportation drives on highways anyway. So, anything you can do to fix highways you are helping out the buses, the van pools, the car pools, the HOV lanes and so forth. It is clear, however, that ITS has really broadened from what some of the people thought it was early on. Other names have been considered. There was one called Electrans, as I recall which was considered, and that sounded more like it was an electric automobile organization. We are not even sure, as I suggested whether ITS is the right name and whether two or three years from now that may not fade away, but in any event ITS is a multimodal thrust, and in the Department of Transportation they are putting together an ITS directorate, and it will be a multimodal operation. not just intermodal. having to do with making the seams work better from one connection, from one mode to another but dealing with the various modes of transportation as a whole.

MR. JOHNSON: I have a question for Mr. Costantino. What is being done to try to establish federal technical standards so that each transportation authority across the nation is not custom designing ITS systems for its locality?

DR. COSTANTINO: The whole business of standards is a very difficult and complex issue. It is not just a national issue. It is not just a state issue. It is, also, an international issue, and there are standards making bodies like the IEEE and the ASME and the SAE who deal on a national basis with those and the international standards organization, the ISO that deals with standards across the board. We have set up, under Bill Spritzer, a special group of people in the United States working in the international arena to try to standardize on an international point of view. In this country, however, our advanced public transit committee made the recommendation on a standard for public transit. So, the first ITS standard, if you will, that has come out on a national basis has been a public transit standard. So, we are working in that area. It is a very important point.

MR. DEEN: Hank, and then we will get to Steve.

MR. DITTMAR: Quickly on the name issue, I guess I would disagree a little. I think names are important. We have argued that the national highway system should be a part of a national transportation system and the same I think we would say for ITS because what you name something is what people think about it, and if we are thinking about the vehicle highway interaction and the name, that sort of says that defines the universe. So, I think it is important, but I would agree with Jim that names are not enough. We went through a process in the seventies to rename our state highway departments as state departments of transportation, but we didn't go through a process of re-engineering, of changing the mission throughout the organization, and so, I think names are important, but they are not enough.

^{*} In August, 1994, IVHS America officially changed its name to ITS America

MR. SHLADOVER: I am Steve Shladover from the California Path Program at the University of California. I would like to ask about the much broader issues that we are dealing with here of overall transportation

policy. There are about 100 of us in the room here, but there are about 250 million people out in the country whose interests have to be reflected in what we do, and the vision that we are talking about generating. How do we generate a vision that reflects the preferences of that population as a whole, since they are the people who are going to have to vote on allocation of resources? They are going to have to be involved in many of the difficult trade-offs that we get into because none of these visions come for free. They are going to involve allocation of public funds, and if the public is not pleased with the way those funds are being allocated, they will revolt, and we have already seen that in the reaction to even modest increases in the gasoline tax.

DR. DITTMAR: I think the tools for a lot of this were laid out in the ISTEA legislation, and they need to be adopted by DOT and by ITS AMERICA as an industry group as well. The tools are really crafting metropolitan vision for what things need to look like. The tools are public involvement and public participation and public involvement goes more, goes beyond having five or six hearings around the country. It really involves focus groups and surveys and translation of this very technical information into what it means to people. That is why I would suggest unbundling these user services from sort of the transportation system function and relating them back to what they mean to individuals and people because until we translate it, we are not going to really touch anybody. So, I think part of it is rethinking our goal structure so that it is meaningful to individuals, and part of it is deriving an outreach methodology that goes beyond having public hearings.

MR. JOHNSON: The one thing I am sure we shouldn't do is go around and try to develop a vision by taking polls and seeing what people want and therefore that is the way the system works. If no one ever does any dreaming, in light of the constraints, in light of the new policy changes imposed by the ISTEA legislation, in light of emerging technologies that we are here today about, then we won't be able to move forward. You know, Chicago had somebody called Daniel Bemham, and it was, thank God, that he had a dream for Chicago and had the energy to keep fighting for it. There are so many things happening that people have to see in action. Right now there is a retrofitting of a major station on the rapid transit line in Chicago under way. Its alternative schemes are being considered. You do not just create transit centers. You create transit centers that are, also, socioeconomic centers or they are markets, and some very exciting things are happening incrementally that help you to think about a much broader vision and to sell that vision as people say, "Oh, you mean I could actually take the train. I could get off the train and I could make my little market stops and drop off my cleaning in the morning, and life would be so much more convenient for me?," and they begin to see new possibilities. So, I think this is how the process has to work.

MR. DEEN: We are in one such area right now. I can remember driving through here years ago on the way to work, riding the bus through this very area when it was all just a bunch of boarded up stores, and now, it is moving in the direction you are talking about.

MR. GREENBERG: My name is Allen Greenberg. I am with the League of American Bicyclists. I have one comment and one question. The comment is on an answer you just gave, Mr. Costantino to a remark that two-thirds of travel is on highways so that most of the applications for highway purposes would address transit and other modes. I just want to comment that while that may be true, there are safety and competitive issues when you compare what modes are advantaged when you take certain measures, and it is not good enough just to say that by helping highways in general you are going to help these modes. Bicyclists are concerned primarily with highway issues, but many of the concerns we have are with increasing traffic speeds, etc. It may hurt our safety and our ability to travel.

I do want to ask one question, and it follows up on a question that was asked earlier. Mr. Johnson, I think your vision showed a lot of foresight, and it is a vision I think many of us share. Admittedly, I think you articulated it better than any of us could, and there was a question about how the ITS architecture program was going to help advance that vision. Mr. Costantino, you said that you envisioned bringing in more people and broadening the process to make sure that indeed it does broaden its perspective. Just speaking for one organization, I went to a subcommittee meeting of ITS AMERICA at TRB, and I was informed that the next meeting I would go to, if I

indeed, wanted to go to another meeting would cost my organization \$1000 membership fee. We do not have that kind of money. I know I speak for many other organizations, and we are certainly not sure at this point that ITS AMERICA is representing our interests.

If you truly want to represent our interests and that architecture report mentions the interests of bicyclists many times and pedestrians, our organization and none that I work with has been consulted about these things. How could our interests possibly be represented in this context?

DR. COSTANTINO: Let me see if I can answer both your questions. In the first place, my comment with regard to two-thirds of transit travel being on highways had to do with the name change, and that is why I was suggesting that maybe ITS even has some application to public transportation. I do agree with Hank. I think the name does have some important perception questions. However, as the executive director of ITS AMERICA, I want to be neutral on the issue publicly. Secondly, with regard to membership, any organization, no matter what it is, whether it is the Boy Scouts or what it may be has to have some kind of membership and membership income, and ITS AMERICA is no exception. If the Federal Government pays for ITS AMERICA, then we become a tool of the Federal Government, and we would prefer that not to happen.

There are many ways that you can participate in the activities of ITS AMERICA without being a full-fledged member. Anytime our coordinating council meets, for example, and anytime our board of directors meets as another example, that is listed in the Federal Register at least 30 days ahead of those meetings, and those meetings are open to the public. Anybody can speak with prior notice to get on the agenda. But the meetings that you may be talking about are working group meetings where draft material is taken up, but nothing ever becomes a decision of the coordinating council or a decision of the board of directors unless it is discussed in open hearings, and those open hearings are listed in the Federal Register, and you can participate.

The fact that we have grown in 1000 days to over 500 organizations would have me believe at least that whatever it is that we are doing, we must be doing something right.

MR. ROUDEBUSH: I would like to say that I think that the change of name from ITS to ITS is far more significant than we are quite realizing. You are being invaded by the environmental movement in no uncertain terms, very clearly and succinctly. Furthermore, you are backed in doing that by federal legislation and national transportation policy as of right now.

So, I would recommend a conceptual understanding of what the environmental movement means. I think we have a great tradition in building the interstate highway system which was built on the basis of defense, and that meant short-term decisions. It meant knocking things aside as we were doing it and putting things aside for a single purpose. The environmental movement is coming to you with a new vision of pay attention to the long term and consider it as importantly as you consider the short term. The solutions which will drive ITS are solutions that serve both those diverse interests and not either one or the other independently.

MR. DEEN: Was there a question embedded in there somewhere? That was an articulate statement, and it was a visionary statement.

MR. BURRINGTON: My name is Steve Burrington. I am with the Conservation Law Foundation. I have two questions for the panel. The first one has to do with the vision that is driving most of the ITS work that is being done today. I found Mr. Johnson's vision very interesting and compelling, but I think there is an alternative vision that in fact is the one that is probably driving most of the work being done.

As I understand it, most of the ITS work that is going on now involves increasing the throughput of major highways and increasing the use of alternative routes, and I think that it would be important to articulate the vision of the future that involves, what that means for how that could be reconciled with the effect on property values it might have in neighborhoods, that sort of thing. In other words, I do not think that the vision articulation should occur just on the one side. I think that it should occur on the other side as well, and I would be interested in hearing if anyone has articulated a vision in which we have say, 300 percent greater throughput on our interstates, and we have much greater use of alternative routes.

My second question has to do with pricing. People have mentioned pricing at a number of points in passing and mostly they have spoken of congestion pricing, but it seems to me that we have not updated our thinking about pricing to match up to the new opportunities that some of these technologies would involve. We can talk about things that are very different from the stupid tollbooths we have sitting out there today, and I shouldn't be talking about when we are introducing something very new in the way of technology taking the opportunity that that presents to change the dynamics of pricing, the politics of pricing. For example, we could say to people that perhaps we are going to make a revenue neutral shift to driving fees from the property taxes and income taxes with which we now pay for many transportation-related services. We will make a revenue neutral shift, and we will charge people using technologies that are dramatically different from the tollbooths we have now. Perhaps we will have remote reading of odometers and again, people will pay mileage fees perhaps on a monthly basis but the whole thing would be revenue neutral. The general question is can we break out of the sort of gridlock that the discussion of pricing has been trapped in so far and overcome some of the political problems that have bogged down.

MR. DITTMAR: I have spent a good part of my recent career working on pricing issues. I think that while ITS allows us some different ways to collect prices, it allows us to charge for transportation regardless of mode used and so it resolves the technological problems. But in the San Francisco Bay Area we found that the problem was not principally a technological problem. We found the problem was principally a political problem, and it was a perception that the public wouldn't put up with these changes, and as we talked to the public we found that their resistance was not as high as the political resistance.

So, I think that while technology will aid in implementation, the questions of education, public willingness and then the question of the impact of these pricing schemes on various segments of the population are critical to deal with. ITS technologies can help you answer those questions, but I think those are the principal questions, and the perception that pricing will hurt the poor is the top thing on the agenda to answer.

MR. DEEN: I think we are running out of time, but this lady has been very patient. So, we will take her question. You will have the last question.

MS. WILLIAMS: Since this is a policy conference, I just want to comment on the fact that it is very important as we go forward in the next day and one-half remaining that we think about the role of the private sector and the kinds of public policies that can be, or at least the drafts of public policies that we can make to encourage the private sector's investment in this new future. I think that since the representation here is largely public sector oriented that we be very mindful of the kinds of policies that could encourage that involvement, particularly in the deployment phase with things like tax credits, etc.

DR. COSTANTINO: I gave half an answer to a question concerning membership in ITS to someone who represented a small group, and I wanted you to know that you had said it was \$1000 membership, but the board of directors of ITS AMERICA has suggested that we could subsidize memberships of public interest groups up to a particular number, and that number is \$250 which is less than the cost of the postage and paper that we send to you. So, if you would like to participate, you can do it at a much cheaper rate than \$1000. That was done six months ago, and we publicized it, we thought, and we have only had four or five takers on it up until this time, but if you would like to participate please see me.

STATUS REPORT AND FUTURE OPTIONS

Chris Body Senior Staff Engineer, Research and Technology, ITS AMERICA

INTRODUCTION

MR. BODY: It is my honor to be moderating this panel with two of the founders and some of the most outspoken advocates of ITS technologies. I will talk a little bit about ITS and a little bit about how it can positively or negatively impact the environment. At this point we would like to take a step back, level the playing field and talk a little bit about what ITS is and maybe more importantly what ITS isn't.

To me ITS is not just smart cars and smart highways. It is truly an intermodal transportation system that is a seamless transportation system for both people and freight. The ITS video I am about to show you gives a general overview of where we have come from since the end of World War II with urban sprawl and why we are at the point we are today, realizing the problems we have from an economic standpoint, a productivity standpoint, and an environmental standpoint.

With that I will begin the video.

(Video presentation.)

MR. BODY: If you are interested in seeing the rest of the video tape we could show it later tonight or you could attend one of the upcoming ITS Systems architecture forums in the next round.

Our first speaker is Mr. William Spreitzer who is with General Motors Corporation. Bill is the technical director of General Motors ITS Program Office and has been with General Motors since 1961. Bill has just been appointed to ITS AMERICA as the Chair of its Coordinating Council and will serve a three-year term.

STATUS OF ITS PROGRAM DEVELOPMENT AND IMPLEMENTATION

William Spreitzer Technical Director, ITS Program Office, General Motors & ITS AMERICA Coordinating Council Chair

MR. SPREITZER: Perhaps you agree that our nation has the finest transportation system in the world, and we move more people and freight, more miles with greater efficiency and safety than any nation on earth, and yet there are many challenges that need to be resolved and improved.

We have accomplished a good bit over the last 20 years, and even though you know the statistics, we will run through them briefly as a kind of an introduction to where we might go from here. For the motor vehicle, new automobiles presently generate 98 percent fewer hydrocarbons, 96 percent less carbon monoxide and 90 percent less oxides of nitrogen than they did when they were unregulated. In addition, corporate average fuel economy has increased from 17.2 miles per gallon in 1976 to 27.6 miles per gallon in 1992.

The national air quality has improved in the 1970 to 1991 time frame by 66 percent in hydrocarbons, 55 percent in carbon monoxide and 42 percent in oxides of nitrogen where the highway mode is responsible for even larger numbers in the 1980 to 199 1 period. In this time frame reductions of 59 percent for carbon monoxide and 49 percent for oxides of nitrogen, occurred thus evidencing substantial improvements.

In the energy area, vehicle miles of travel have continued to increase but at a lower rate than they might have otherwise. Interestingly the increases in automobile miles traveled are less than 2/10 of 1 percent per year and represent only a modest part of the total VMT increases. Substantial increases have occurred in trucks VMT, both light trucks and heavy trucks, particularly as freight has moved from rail to the highway mode and in increases in air travel and water transportation, particularly in the demands that that creates for the final shipment of the freight by trucks. But this conference is not about history and it is not about accomplishments. It is about the future and about how we are going to use advanced technologies to reach for optimal social objectives, and the number of ways in which that might be accomplished.

Let us be a little more specific. For those cities with air quality attainment problems, the Clean Air Act Amendments require that certain measures be taken in travel demand management. One example is employee trip reductions. It is estimated that we can accomplish a 1- to 2-percent improvement in energy consumption by employee trip reduction measures, and it is estimated further that with all measures taken together we can look forward to about a 5 percent improvement nationwide.

Now, for travel inefficiencies, the estimated total cost of travel inefficiencies is \$40 billion annually, and it has already been demonstrated in several cities around the country that there is a potential for a 9 to 19-1/2 percent improvement in air quality and up to a 1 j-percent reduction in energy consumption simply by improving the existing traffic management systems. Which of these options should we pursue? Obviously, we should pursue all of them as they relate to the needs of a particular community. Which ones should we pursue first? The priorities would depend upon many factors, including cost and also the institutional requirements. Which of them can be accomplished in terms of the questions that are being raised by society generally and particularly by the people who will pay for them? I couldn't help but think in response to a question posed earlier how much of the money will come from the public and how much will come from the private when in reality all of the money is going to come from the taxpayers or in the charges that are incurred against society, and so, we might address that particular question in a slightly different manner.

In thinking about the questions of what and how and what priorities, it is interesting to look at the ITS AMERICA organization and the many opportunities that are provided to participate in the decisions that are being made.

There are many technical committee and task group activities being conducted within the ITS AMERICA organization partnership of public and private interests working together toward definition of future needs and opportunities. In almost every case there is an energy and environmental dimension to the work that is going on and we need to address this in a cooperative rather than a competitive way. It is not a "them and us" kind of an opportunity. It is a "we together" opportunity, and so, I would encourage you to, if you are not already doing so, to participate in these important activities.

As Jim Costantino has mentioned there is room and need for everyone and yes, you do need to be a member to participate in the committee and subcommittee activities, but if there is a financial requirement, there are ways of accommodating or subsidizing your participation.

Further, these things are nested within a much larger context. That larger context includes not just the former previous work done with regard to a national program plan for the U.S. Department of Transportation activities and the advanced technology arena and the strategic plan for intelligent vehicle highway systems in the United States which was produced and delivered through ITS AMERICA two years ago, but currently there are substantial efforts well under way with regard to a national program plan which will address these important questions of what and who and how and when and how much is it going to cost and where is the money going to come from. And I think Denny Judycki might say a few more words about that in just a moment. But more importantly, to be a part of that process, you truly do need to participate, and therefore, again, there is a strong encouragement for you to come forward, if you are not already doing so, to participate in that process.

Finally. this work in intelligent vehicle highway systems and advanced technology fortransportation purposes is nested within a much larger national activity that has been going on for some while, and there are a number of ways in which you can trace those beginnings by going back to 1985, 1986 and a number of the other speakers this morning have already mentioned some of the activities that are under way.

Within the U.S. Department of Transportation, which I am sure Denny Judycki will describe in just a few moments, there are ongoing programs, a number of contracts that are already out there, operational field tests which now have a requirement for a rigorous evaluation including energy and environmental impacts, and if we have time through the conference, we could talk about specifics in several of the operational tests today, but the systems architecture effort, also, has similar dimensions. The work that is going on in what is called the automated highway systems precursor studies, also, has dimensions in this regard. With regard to implementation and deployment, the activities that are going on within other federal departments, also, relate to this particular subject, whether it is the Clean Air Act Amendments and their requirements, ISTEA and the requirements therein, the American Disabilities Act, the PNGV which was mentioned earlier this morning, CMAP or the technology redeployment program, there are activities which directly relate to the interests and needs as they relate to transportation and advanced technology. We hope that in the national program plan that we will not only be able to take advantage of the 659 million dollars that were created by ISTEA beginning in December 1991, but to build on the justifications, opportunities and the specifics with regard to where we go from here.

The national program plan is in draft form. I expect that maybe half of the people in this audience already have a copy. I was told that 2000 copies were printed and distributed. The intent in the second wave is a set of national workshops to collect inputs and comments with regard to the specifics of the overall plan with the intention to deliver a final copy in November of this year.

Finally, that national program plan is a dynamic and working document. As we move forward and collect the information and experience from operational tests, from the public outreach, from the town forums and councils which will be held from meetings such as this and importantly from the meetings and activities of the technical committees and task groups of ITS AMERICA, we can put together the plan, which, as I said earlier, will be helpful in all of us collectively and cooperatively working toward the use of advanced technology to work toward an optimal society.

MR. BODY: I might note that a copy of the program plan is available in the lobby, and if you leave your business card we will mail a copy to you towards the end of the week. There is, also, information on the national workshops which I believe are coming up near the end of this month.

Our next speaker is Denny Judycki, Associate Administrator for Safety and System Applications within Federal Highway Administration. Highway safety, technology applications and the overall ITS program are under his direction.

Dennis Judycki FHWA

MR. JUDYCKI: I just told Bill that he helped out a great deal in keeping my remarks shorter with what he has covered. We will cover a little history from my perspective and possibly chat a little about some of the activities that are important at the federal level that you should be aware of, although they have been touched upon off and on throughout this morning's sessions.

Those of us who were involved in ITS from the very beginning over the last eight or nine years have grown up with the task of bringing an ITS program forward from the culture of a traffic operation perspective and clearly we were dealing with operationally putting in place activities that dealt with incident management programs from an efficiency of a system perspective. There is no question about that. Yet looking to the vision of something that had been discussed even 20 years ago of advanced highway systems it is remarkable how far we have come. I think that certainly we have been champions as we move along. We have been advocates for the program and hopefully have not oversold the program. But certainly as technology has advanced it became important that we focus on how to manage not only the technology, but to a great extent what we are dealing with is looking towards the capabilities of being able to provide information to travelers that will help us all out in our day-to-day lives.

The fixation on mobility should be set aside. The issue of throughput and capacity is discussed and is important. Operational efficiency of a system is critically important, but I think that as you look at the department's strategic plan, the safety aspects, the productivity aspects, the quality of life aspects that we are all concerned about here has been brought into the program as a dimension that is critically important and fundamental to the success of what we now call ITS within the Department of Transportation.

We have come a long way in the last few years. In fact, the ITS program has really almost become a movement more than it is a program in defining where we are going to be at the end of a given period of time. We started off in 1990, just three or four years ago with a program level, at least from federal resources. of some \$4 million to a program that is somewhere in the vicinity of \$200 million.

Earmarking was mentioned this morning. I think it is probably important to note that there is a lot of congressional interest, as everyone is aware. Last year somewhere in the vicinity of 90-something, close to 100 percent of the dollars that came out of our legislation was actually earmarked for specific projects. Not that all were not good projects I think that that is important to recognize that much congressional interest as to where that money is going and how it is to be used will continue. This year the explicit earmarking is down to some 90 percent of the money that was authorized through the ISTEA legislation. And once again, the authorization is to some very good ITS advancing technologies, institutional study types of projects. Nonetheless, there are still some that we would not have selected if we had gone through a program planning process and put forward those that best suited the national goals and objectives.

I should mention that currently there are probably in the vicinity of 6 to 7 million dollars a year that we are putting into institutional legal issue studies and analysis as part of our program planning to address areas such as societal impacts and environmental impacts. The transition has taken place quickly. It is a comprehensive program that is getting a lot of attention and I think that it is important that it be viewed as part of the bigger transportation picture.

The name change is an issue that we have talked about a little this morning. I will just mention the department is involved in that discussion as ITS AMERICA works towards its board of directors meeting in July. There is no question that ITS to many misrepresents the true character of the program and its content. It is not only an issue of an organizational name, ITS AMERICA, but also an issue of a program name. Obviously there are a lot of stakeholders, including Congress and others, that will be involved in the discussion over the next couple of months as to what it is called and how it is perceived. I think the important thing is something that Jim Costantino brought up and that is that it is an ever-expanding program that, in fact, does have broad goals and a vision that goes way

beyond the perception of the traditional highway program and system and gets at the quality of life that we are all trying to improve.

The user service approach was one of the ways that we used to make that transition from the hard side technologies and looking at traffic management systems to considering the consumer, the user of transportation, as the target of opportunity and the vehicle through which we needed to communicate the program. There was a comment earlier about making sure that those user services were much more directed towards individuals and I think that that is something that we need to consider.

Bill Spreitzer talked about some of the programs and their impact. I am not going to repeat that. I think that we have talked about some of the efficiencies that can be built in through public transportation, traveler choice, efficiencies in traffic control signal improvements and some of the enabling technologies that should influence public policy. That is something that, as you break out into the workshops, you should address because ITS in itself is a vehicle to address some of the broader transportation public policy issues such as congestion pricing. But the program itself is not the solution to getting to the broader public policy issues. It is a forum that certainly will provide some of the enabling technologies and needs to be discussed as the program evolves.

The strengths of the program I think are in the national management of the program. This has grown, although quickly, with strength and it has grown with a conviction that putting together a national program everybody can hold up and align themselves with will give us strength as a nation in moving the program forward. I think that ITS AMERICA has done a tremendous job in reaching out and providing the vehicle through which that discussion can take place. The national program plan is unique. It is a unique partnership in that it is not a document that either carries an ITS AMERICA logo or a Department of Transportation logo or any other logo on the front cover. It is truly intended to be a document that is built throughout the ITS community on a national basis and a product that we will all be able to hold up and say that this is not only the vision of where we should be going with the ITS program but tactically here are some ideas of how to get there.

The uniqueness of that partnership provides an opportunity for all of us to make a meaningful impact, and I would invite you to join that process as it is the opportunity to take the environmental and societal issues program forward to that level that is going to help us to develop the long-term vision that is so important to us.

System architecture is something that has been discussed a couple of times. We will be developing a system architecture evaluation process that will look at both technical as well as societal impacts as we evaluate the system architecture. The schedule that we are on is to, by this fall, have four competing teams that right now are working on system architecture. This fall there will be a more open discussion of those architectures. There will be a selection process in which an architecture will be selected to be pursued more vigorously. About a year and one-half from this fall, someplace in mid-1996, in the summer of 1996, there will be the development of an architecture that we can adopt nationally for ITS. The importance of that architecture process obviously is to develop a framework within which, not only will there be a description of the program and its application, but also an ability to develop standards and protocols that will provide flexibility to our industry with some direction as to how standards and protocols should be developed for application.

Operational test programs have received a lot of attention. There are some, for those of you who have not seen some of the operational tests that were just recently selected, we have just announced another 17 on top of the 40 that were under way already. A few of the new tests are in addition to the major areas of emphasis, such as public transportation, commercial vehicle operations and Mayday alert system operational tests. This round of operational tests focuses attention on environmentally based activities, and we have two or three that we are all interested in keeping our eye on, one in Idaho where the partners will evaluate the feasibility of remote sensing technology to monitor emissions of all vehicles. In that test the objective is to judge the relative contributions of county-based vehicles versus out-of-county vehicles in residuals generation.

Another operational test will deal with the diagnostics of the vehicle itself so that the driver of the vehicle will be better informed as to the nature and quantity of emissions. In Minnesota, there is technology that will be tested for wide-area emissions detection from roadside sites. We think that this adds a new dimension to our

operational test program that will be very important to us in the long term. We will be announcing another operational test solicitation sometime within the next few months and welcome any suggestions as a result of this workshop or individually as to major areas that might prove to be beneficial from the societal benefit perspective.

Finally, I would just suggest that deployment is the key. If, as Tip O'Neill said, "All politics is local," then all deployment is local, too, and we can certainly open up the process and assure ourselves that we have a national vision for the ITS program that is consistent with reaching out and providing societal benefits as well as mobility, safety and productivity. But when you come right down to deployment, deployment is going to be the judge of not only the marketplace but, also, of state and local government adoption as application takes place throughout this country with product services, institutional arrangements and public-private partnerships that have value. Those deployment activities need to take place through traditional established institutions. The MPO's must get involved much more aggressively in the process than they are right now. Certainly local governments must address some of the policy issues that are facing us. such as pricing, that are so important if, in fact, we are going to use ITS as an enabling program.

Again, my charge would be that you look at the program plan as an opportunity to become more actively involved. I would suggest, as mentioned earlier, that the involvement be much more than just commenting through a federal docket exercise or through a series of outreach meetings stating that the program plan is being put together by a group of volunteers who, to a large extent, are rolling up their sleeves, sitting around a table and providing input as to what that vision, what the tactical element should be in order to proceed with the ITS program.

Thank you very much, and I look forward to working with you in the workshops.

MR. BODY: Please join me in thanking both of our speakers for the interesting perspective on the past, present and future capabilities of the ITS program.

Tom Horan has a couple of announcements before we break for lunch. Our lunch speakers today are Fred Krupp, the Executive Director of the Environmental Defense Fund and Larry Dahms, Executive Director of the Metropolitan Transportation Commission.

DR HORAN First, what you have heard this morning started out with the vision of ITS. Now we have heard some of the program details and the program plan so that we all have a sense of the landscape.

This afternoon, after Fred and Larry Dahms, whose talks will begin at twelve-twenty, have finished, we will hear some of the papers that have been prepared for the conference. We then move forward to hear from you through the breakout group discussions and what you think the priority issues are.

JOSEPH L. FISHER MEMORIAL LECTURES

Dr. J. W. Harrington Director, Graduate Public Policy Programs, George Mason University

INTRODUCTION

DR. HARRINGTON: I am very happy to be here and thrilled to present our two Joseph L. Fisher Memorial lecturers. First, I would like to introduce you to Mrs. Fisher and ask if she would stand. I am very happy that you could join us today. I will introduce each of our lecturers in turn and then remind us of the vision and accomplishments of Joe Fisher.

Our first speaker, Fred Rrupp, is the Executive Director of the Environmental Defense Fund, a national environmental organization that links science, economics and law to create innovative, economically viable solutions to today's environmental problems.

Mr. Krupp was a key figure behind congressional passage of the Clean Air Act which employs an innovative and economically sound EDF acid rain reduction plan, and behind the McDonald's Corporation's decision to adopt a 42-point solid waste reduction plan including the phase-out of the foam clamshell boxes. Since Krupp joined EDF in 1984, its annual budget has increased from \$3 million to more than \$20 million. Full-time staff has nearly trebled from 50 to 140. Membership has expanded from 40,000 to more than 250,000, and new regional offices have been opened in North Carolina and Texas. A member of the President's Council on Sustainable Development, Krupp serves on Governor Cuomo's Environmental Advisory Board and on the boards of Resources for the Future, the National Environmental Education and Training Foundation, the Connecticut Fund for the Environment and Columbia University's Lamont-Doherty Earth Observatory.

Krupp is a graduate of Yale with a law degree from the University of Michigan. He has been a visiting fellow in environmental law at both schools.

Our second lecturer, Lawrence Dahms, has been Executive Director of the Bay Area Metropolitan Transportation Commission or MTC for over 16 years. He serves a 19 member governing board composed almost entirely of local elected officials. They, in turn represent the nine counties and 100 cities of the San Francisco Bay Area. Mr. Dahms' career has included positions with the Army Corps of Engineers, California Legislative Analysts, BART, ADL and CALTRANS. He is a member of the boards of directors of the ENO Foundation for Transportation, ITS AMERICA, Californians for Better Transportation and past Chairman of the Transportation Research Board Executive Committee.

In addition, he actively supports the work of the National Association of Regional Councils and American Public Transit Association. Larry has a BS in civil engineering from San Diego State University and an MBA from Sacramento State University.

Each of our lecturers has agreed to limit his presentation to 15 minutes which is a shame given their expertise, but a necessity given our schedule today. There will be no Q&A at the end. I hope that if you have some burning questions that you will be able to talk with each of them immediately following their presentations.

Joe Fisher, for whom this lecture set is named, was born in Pawtucket, Rhode Island in 1914, where he gained a love of the wilderness. He attended and graduated from Bowdoin College in Maine and spent the years 1935 to 1945 as a resource economist.

After military service during the Second World War, Joe and his wife, Margaret or Peggy as she is known, moved to Cambridge. Massachusetts, where Joe earned a Ph.D. in economics.

From 1947 to 1954, Joe served as Executive Officer and Senior Economist of the President's Council of Economic Advisers. In 1954, he joined Resources for the Future and became its president in 19.59. He remained at Resources for the Future until 1975, because in 1974, he was elected to Congress from Virginia's Tenth Congressional District. Fisher's public service continued in 1982, as Secretary of Human Resources in the cabinet of Virginia Governor Charles Robb.

In a brief biography, Reverend Ken Beech writes, "Looking back upon his public career Joe Fisher took the greatest pride from his contributions to federal environmental policy and his successful role in creating the Bill of Rights for Handicapped Persons in Virginia."

In 1986, Joe was appointed distinguished professor of political economy and special adviser to the president of George Mason University, where he served until his death in 1992.

He wrote extensively for academic and policy audiences. I will close by quoting from two sermons he wrote for Unitarian Universalist sermons with his wife which relate directly and eloquently to our purposes here today.

First, "Environmental protection has to be approached as an all-pervading strategy at all levels of government and society; education, prohibition, economic incentives, international conventions and changes in personal behavior will all have roles to play. New compromises that sustain both the economy and the environment must be arranged." Finally, "Inspiration, the necessary forerunner of great thoughts and great actions comes out of a depth of experience out of an awareness of living, in this case the experience of living with and in nature. Emerson advised, "Hitch your wagon to a star." Did he mean "aim high" or "align yourself with nature"? I think he meant both. They are one and the same."

Fred Krupp Executive Director, Environmental Defense Fund

MR. KRUPP: Thank you, J. W., it is a great pleasure to be here and a special honor to be associated in this way with Congressman Fisher's good name. I have followed his career for years and am, as a part of Resources for the Future, familiar with the wonderful course he charted for that institution. as well as his good work on the Hill.

In listening to your introduction of me, J. W., and you choosing the McDonald's story to highlight, I remember well when we at the Environmental Defense Fund, a national non-profit environmental group, better known in the early years for suing than working with big businesses, decided to embark on this course in 1989, of working with McDonald's, one of the biggest corporations in America, we thought we were taking a little bit of a risk, and McDonald's thought that they were taking a bit of a risk working with us.

It could have turned out differently. As a matter of fact, the anxieties that we had in entering into the relationship continued even after the 42 point plan was adopted. Editorial writers around the country praised the idea that, now in this new era, environmental groups and businesses can work together. We were quite anxious about being criticized from the left wing, and we heard one day that indeed, a weekly paper called the Rolling Stone was going to do an expose of why EDF would work with McDonald's.

I went off on vacation, and when the article came out I had given instructions that only if it was bad send it to me right away, otherwise I wanted to be on vacation that week, and much to my chagrin I came home one day with my three little boys and my wife from the beach, got back to the place we were staying in, and on the doorstep there was this Federal Express package.

I put my three boys to bed and opened the article, and surprisingly even Rolling Stone was congratulating the environmental movement for maturing to the point where it could work with a big corporation and get something good done, but then I came to the damning line, which happened to be a description of me, which caused the offrce to express mail it out to me. It said, "Fred Krupp, the slightly nerdy" -- "but persuasive Executive Director of the Environmental Defense Fund." I handed the article to my wife. It was mostly good about what we had done anyway except for that line, but when she got to that line, she looked at me, and she said, "Fred, you didn't tell me that the reporter interviewed you in person for this piece."

I did tell that story to my board of directors using it as an example of how they really had to pitch in and influence what journalists were writing about us, and in fact, it turns out that the reporter is a young fellow whose father is a partner with one of my board members, and I said, "Now, come on, if we were doing things right we would have given a more favorable impression of me," and the board member shot back, "You do not understand, Fred, it was thanks to me the word 'slightly' was inserted."

Anyway, I am delighted to be here. I am delighted to have the Environmental Defense Fund cosponsoring this conference. It is great to see engineers, environmental experts, community leaders, corporate and government officials all seeking common ground as we assess the tremendous new technologies that will shape America's transportation future.

This is an effort that I believe is vital to our environmental, as well as our economic health because transportation is so vital to both of them.

By focusing on innovations that can reduce pollution, serve all communities and make economic sense, I think we can help assure the future quality of our life in our cities, our suburbs and even our rural towns over the next century.

This morning it was described that intelligent transportation systems including intelligent vehicle highway systems will have a major impact on our life style and our communities in years to come. I think the advanced

information and communication technologies can give us a much more accurate picture of the flow of goods as well as of people, the use of energy, the production of pollutants, and in general a much clearer picture of all that is going on in our transportation systems than we now have. More data, better accounting of the true costs of the various options will allow consumers, communities and corporations to make informed, truly intelligent transportation. The interesting thing about these systems is that they can feed on the flow of data and become self-managing once we decide what the goals are.

As we are deciding how to improve a transportation system or to prevent pollution or to reduce waste, I think some principles apply in all fields, and that is that we get the best results from processes that set high goals but encourage flexibility and innovation in achieving them or better yet surpassing the goals we set. At the Environmental Defense Fund, we spend a lot of time looking for opportunities to make America's two-decade-old system of regulation more effective and efficient.

I think the need for improved transportation decision making is clear because there is a real frustration growing among Americans with large government bureaucracies that often fail to produce the promised results. I think the only way we are going to build political support for greater breakthroughs is to find methods that produce the maximum results at the lowest cost, and that means developing completely new types of regulations, ones that set strong performance standards and use incentives to encourage innovation in how we attain those standards. The concept really is simple. It can be boiled down to a few words. Here is the target. Hit it by any means you can that does not involve cheating. Miss it and you pay.

I think too many of our existing statutes are unnecessarily complex, redundant, rigid, costly, and to me even incomprehensible at times. The whole assemblage of laws sometimes looks more like a Rube Goldberg apparatus than a smoothly running machine. The time now has come to forget about one-size-fits-all standards that apply to every factory or every facility and look for a new way because the one-size-fits-all mentality makes the environment a loser. The standards typically are watered down to the lowest common denominator when we could achieve greater pollution reduction with more incentives and more flexibility. What is more the top-down mandates and many environmental regulations offer no incentives for bottom-up innovations that are often best found "on the factory floor."

In the transportation sector it is less than crystal clear from the outset how these principles apply. What we do know is that intelligent transportation system technology can be an important tool to promote win-win results. The integration of information communication and control systems technology already have occurred in other places in the economy and massive gains in efficiency have been achieved. These tools can help us, in a major way, address the key problems in transportation.

Intelligent transportation technologies on roads, for instance, and in cars and trucks and buses that are currently being developed by hundreds of companies and public agencies are being refined, I think, before we have clearly identified what the goals are. As we are poised as a society to invest so heavily in such projects, we have to develop the analytic capability to evaluate the likely impacts, as well as define what is it that we are trying to achieve. On the analytic side I am very pleased to see the Department of Transportation has recently increased funding for this type of modeling, but so far we are concerned that the development of these technologies has followed a course that threatens to repeat the mistakes of the past, increase suburban sprawl, air pollution and dependence on automobiles and imported oil while further reducing the ability of people to walk or bicycle in their communities.

I think there is a danger that intelligent vehicle highway systems will simply extend the problems that we have now, an overdependence on subsidized automobile transportation, an overdependence on the land use mistakes we have made in the past.

Nevertheless, appropriately directed, intelligent transportation systems can be a vital tool for using market-based mechanisms to improve air quality. They can help speed the integration of demand management and transportation opportunities in planning, as well as to more fairly assess road use and parking fees.

Such systems can reduce the large and hidden subsidies that now encourage overdependence on the automobile and they can help shift the financial burden for maintaining these systems away from taxpayers to the highway users. Thus, market forces can spur the development of new smart public and private transportation services to better meet the fast-paced demands of the next century.

My hat is off to outfits like Federal Express who have created ingenious uses of computerized information flow systems to move parcels from point to point, but in a country where we value people and their time and their health, including protection from air pollution, perhaps more than parcels why not use intelligent transportation systems to create transit and paratransit options for people to move from point to point speedily and safely with less congestion and air pollution?

This is largely unexplored territory that demands simultaneous and coequal development as the system is designed so that we are paying attention not only to increasing the number of cars we can put on our infrastructure but increasing the ability of people to move efficiently and cost effectively from place to place.

This applies to freight, as well as people, of course, and I want to, also, say that what is key is that when we move into designing and deploying new ITS systems, we need a public-private partnership that will require broad acceptance from the general public, and that will require a more participatory approach.

The legitimate goal for me that intelligent transportation systems can help achieve is to squeeze extra capacity out of the existing infrastructure. That is a legitimate goal. It is one, making our neighborhoods safe for pedestrians and bicycles; and, actually facilitating such uses. Reducing accidents, saving lives is a third goal and a fourth is using these systems to increase transportation efficiency, defined as reducing pollution per passenger mile traveled or per pound of freightage traveled.

The point though is not so much that EDF should be defining what are legitimate goals, but that the public has to be included in the process, and that projects, to be worthy of support of the Department of Transportation and Secretary Pena's fine reputation and to be worthy of this country, we need to have an open process. It is no secret **that the** Environmental Defense Fund has been constructively critical of ITS AMERICA, suggesting that charging a fee to participate is inappropriate, more than that unacceptable.

We appreciate that a discount has been afforded to six groups, but the fee should be waived entirely for any non-profit group that requests membership. We appreciate that the FHWA has thanked us for our views, and we will appreciate swift action by FHWA or Secretary Pena that corrects this unfortunate exclusionary practice.

When \$300 million a year of public dollars are going to be spent to develop this powerful new technology, public participation should be embraced, and those who call for it should not be accused of, quote, creating disruption and potentially damaging the perception of ITS AMERICA.

The damaging perception is created by the exclusionary practice. It is time to broaden the board of ITS to include environmentalists. It is time to get on with opening ITS AMERICA up, if it expects to play a role advising the government of this country on such an important new technology.

Minimal targeted modifications in the design and structure of intelligent vehicle highway systems would enable local authorities to limit speeds electronically on selected roads, reduce motor vehicle accidents, air pollution and energy use. Such a strategy could produce more livable communities. It could also lead to the development of air pollution reductions that could be traded under the Clean Air Act as mentioned earlier. Ultimately these systems could allow us to achieve simultaneously pollution reductions, efficient transportation, a stronger economy and a healthful environment. That is the challenge for all of us. That is the challenge for ITS AMERICA. Working together I think we can find ways to achieve our legitimate multiple goals simultaneously.

Lawrence Dahms Executive Director, Metropolitan Transportation Commission & Chairman, ITS AMERICA Board of Directors

MR. DAHMS: I join Fred in being honored to be associated with Congressman Fisher in this program. I prepared for this session with the idea that I am a representative of ITS AMERICA addressing an audience of environmentalists.

The conference attendance list, however, reveals that only approximately one in five here seem to be identified with environmental groups. My presentation will work anyway, if I am able to assume that the ratio simply reveals there are more in the transportation community interested in the environment than there are environmentalists interested in transportation.

In a recent ITS review article entitled ITS and Social Policy, Pat Waller asked, "What have we learned in the last 35 years, and how can we use our experience to improve the decision and policy making processes as we embark on the next major era of transportation in the United States?"

Pat then begins to answer her own questions as follows: "First and foremost we need to reconsider how we envision the role of transportation in our society. While historically transportation has been defined as the safe and efficient movement of people and goods in our society, it is far more than that. In America today, transportation is an essential component of health care, education, employment, recreation, culture, maintenance of ties with family and friends and all that makes life worth while.

"Transportation is what enables individuals to become full-fledged participating contributing members of society and what enables communities to work the way they can and should. In this day and age and in this society transportation is a necessity. We need to recognize that when we make decisions concerning infrastructure, highway location, modal choice and intermodal facilities we are in effect making social policy. We do so either inadvertently as was often the case with the interstate highway system or consciously and conscientiously as is our option at this point in history."

I am sure that Pat would agree her conclusions that the impact of transportation decisions extends to the environment as well as social policy, and that after all that is why we are here today, to advance the cause of mobility in the context of beneficial environmental and social policies, but that we all know, is much easier said than done. To capture the challenge as it applies to intelligent transportation systems consider how David Burwell posed it in his ITS review article, Is Anyone Listening to the Customer? "A struggle looms over the heart and soul of the ITS program. What are its objectives; who benefits; who pays and who decides? The answer to none of these questions is clear, but ISTEA with its broad, multiobjective mandate makes it clear that these questions are too important to be left to the vendors of ITS systems alone."

David is right. Intelligent transportation systems: What are the objectives? Who benefits? Who pays" And especially, who decides? I would like to posit that the question of who decides is central to the goal of promoting social and environmental objectives.

Just as the medium is the message, the process is the product when it comes to complex transportation decisions. To the extent that the decision-making process embraces all the interests with a stake in the outcome, the final product is going to be responsive to environmental and social needs. David concludes it is all too important to leave to the vendors alone. I think the vendors would agree with that, too. The engineers among them might even identify as I do with Senator Moynihan's observation, "Theirs admittedly is an unjustly maligned profession. Nothing in the training or education of most civil engineers prepares them to do anything more than build sound highways cheaply."

Having launched my career as a civil engineer, I would only quibble with the adjective "cheaply" found in this quotation. So, the vendors in the audience and I are tarred with the same brush by David Burwell and Senator Moynihan of having perspectives that are too narrow to satisfy the more demanding objectives of a transportation system, be it intelligent or not. We admit it, must correct it and must get on with it. If we can stipulate then that the disparate points of view of the attendees of this conference and of a wider range of individuals and organizations not represented here are all critical and need to be included in answering the who decides question, then how is that to be accomplished?

In large measure the marketplace is already deciding and will continue to decide. The intermodal community, for example, is not waiting for U.S. DOT or ITS AMERICA. It is making effective use of information processing in order to satisfy real live customers right now.

As David Burwell suggests, however, the level of public investment in the ITS industry demands and deserves a more deliberate approach to resolving the who decides question. Here ISTEA steps in as a powerful catalyst characterized as the cusp of a revolution by former TRB Chairman and University of Virginia ProfessorLes Hoel. ISTEA is about many things, most importantly explicit recognition of the power of partnerships to reconcile competing objectives. Thus, the act that authorized major funding for ITS research and development, also, mandates extensive outreach in its conduct.

Central to the extensive U.S. DOT and ITS AMERICA outreach program is the system architecture program. Noble as its intentions may be to be inclusive and as important as the architecture program is, it falls short of achieving sufficient expansion to answer the who decides question adequately for several reasons. First, it suffers in perception at least because it is directed by teams of vendors. Second, at this early stage it is not yet well enough defined to permit incisive analysis by outsiders. Third, it is at once both too comprehensive and too complex for almost anyone new to the scene to grasp, and finally, and probably most importantly in the long run, the architecture program focus is on compatibility of interacting designs of individual components of the system or systems.

This compatibility objective is worthy and necessary but it does not necessarily address the larger questions of social and economic policy.

Another series of opportunities for participation is found in the field operations tests. There are now, I say almost three dozen, but Dennis Judycki noted a minute ago more than 50 spread around the country. So, it is impossible at this stage to generalize as to any common thrust. My organization is the cosponsor and manager of one, Trav Info. It will collect real time system performance data to be formatted for immediate access by the public to assist in trip planning and route corrections. The public-private partnership experience epitomized by ITS AMERICA is extended through Trav Info to the San Francisco Bay Area where we have nearly 50 new and active players from Silicon Valley and defense conversion sectors advising our Trav Info development team.

The choices to be made in the design of Trav Info, however, tend to focus on the ultimate division of labor between public and private providers of the information and the extent of information available to the general public versus packaged for specific audiences.

This field operations test then only begins to scratch the surface of the social and environmental questions that may be of interest to the audience here today. U.S. DOT 's early deployment grant set the stage for another broad range of discussions concerning objectives to be served and trade-offs to be made as the use of emerging technology is considered.

In theory, at least this offers the chance to consider a broad range of regional objectives and choices. Here again, my organization is the manager of a project funded by U.S. DOT. The promise of this broader viewpoint depends particularly on how well my agency and my peer agencies involve a broad spectrum of interests.

For U.S. DOT, ITS AMERICA and the environmental community, a second challenge is gleaning common threads of opportunity from these far-flung exercises. This general review of the processes in place to begin to answer David Burwell's who decides question probably is beginning to sound to you, as it appears to me, to be all

too abstract. So, to liven things up some, let us consider the nature of some of the choices that will have to be made. Based on our experience in the San Francisco Bay Area to date, some examples have emerged, such as the choice between sectors, that is public and private associated with Trav Info as I have already discussed.

There are, also, choices between levels of government responsibility as in the case of freeway ramp metering that smooth the flow on the state system but at the expense of local system problems at least as seen by local officials in my community. There is a choice between system expansion in the form of more lanes and interchanges versus system operation devices and strategies as envisioned in CALTRANS traffic operations system of which ramp metering capability is but one part.

MTC will adopt its first regional transportation plan, guided by the stringent financial guidelines of ISTEA later this month. The expansion versus operations and maintenance debate was pronounced in the extensive outreach employed in the course of writing the plan. On the near horizon are other interesting choices to be made as pointed out by others such as Pat Waller and Tom Sheridan in the latest ITS review.

In discussing questions of equity Pat Waller observes that the public investment in system access can produce uneven benefits. For example, she notes while safety belts are effective in and of themselves, a Mayday signal is useless without a support system that detects the signal and relays it to another responder system that provides care and transportation to a health care facility.

While public monies provide these support systems, "will only the affluent reap the benefits in the near future?" Do we have feasible choices to make in remedying such circumstances as raised by Pat?

There are even choices between the influence of professions. Tom Sheridan points out the conflict in the viewpoint of attorneys and human factors engineers as follows from his article. "Product liability attorneys insist that products are defective unless there is a warning against just about every conceivable misuse, as either a display, a panel label or an item of operating instructions. However, common sense, well corroborated by human factors research, suggests that there is a limit to the number of different displays or warnings that an operator can tolerate and that the best way to minimize accidents is good design with necessary information sufficiently integrated to allow the operator to perform the primary task reliably." And, of course, there are choices to be made in the application of our new-found tools. Truckers, for example, appreciate the through-put opportunities offered by use of transponders but worry about the pricing and regulatory uses of these tools.

We will make some of these choices as part of a regional process and others will be pre-empted by the market or national decisions. Thus, as regional players we are as concerned and as challenged by the who decides questions as this audience of environmental players is. Now. lest I lead you astray, I do not want to imply that once we iron out the who decides, who benefits and all the other fundamental questions that all will be smooth going for intelligent transportation systems.

In an article by Don Camph for STTP, he calls attention to the quote, high-sounding policy statements that can be found in transportation bills going back 40 or more years. In praise of ISTEA he observes that the reason it is a step forward is that it translates a policy vision into specific provisions linking general policy direction to both planning requirements and funding mechanisms which he then describes.

I share his optimism but I am painfully aware of the wrong turns that can be taken on the road to implementation. An article in the Urban Transportation Monitor dated. May 13, may help to explain some of the difficulties that lie ahead. It describes the conclusions by the Federal Highway Administration after conducting 35 workshops involving more than 1400 professionals involved in incident management.

What did FHWA discover? Policy decisions made by management often do not find their way to the operator's level or are misunderstood. There is very little knowledge of any agency's capabilities by members of sister response agencies. The level of cooperation that exists among agencies is not nearly as great as it is perceived to be and the best state-of-the-art equipment is wasted if the agencies do not talk to each other.

If this partially describes the results of interaction among professionals having fairly narrow and common objectives performing long-standing joint functions, what does it portend regarding the results of policy decisions made in Washington irrespective of whom the "who decides group" is?

Such long-term concerns aside, there is an excitement that naturally flows from the search for structure in an inherently unstructured world. I like to think of my own organization, MTC, as an experiment in good government where process is our most important product.

As such, we are at the apex of a little slice of democracy. Our basic task is to bring partners together to produce better decisions about mobility and the environment. In a technically much more complex environment and on a national scale, ITS AMERICA is an experiment in public-private partnership also operating as a little slice of our democracy. In its short life, ITS AMERICA has moved from civil engineers to a wide spectrum of system engineers and now struggles to embrace a much wider audience.

Such is the natural evolution of an organization aspiring to improve mobility in a positive social and environmental context. Even a name change is likely from ITS to ITS America or It's America. It's America where everyone has a voice and must be encouraged to use it.

DR HORAN: Thank you very much, Larry, Fred. Next we have presentations of some of the papers that were written for the conference. I would note by way of introduction of these papers that we have heard a theme develop, an organizational theme about ITS AMERICA or not ITS AMERICA. That is one important subject of the conference. There are several additional subjects to the conference regarding what environmental impacts should be considered what kind of impacts they might be, and what social impacts might there be, and these are all the subjects of the following presentations and papers to follow.

Mr. Lee Munnich is a senior fellow and director of the State and Local Policy Program at the University of Minnesota will moderate these presentations. Lee has been a key participant in the planning of this conference and in guiding the development of the papers which you all should have and which were cosponsored by CALTRANS as well.

CONFERENCE PAPERS

POLICY OPPORTUNITIES AND CONSTRAINTS

Moderator: Lee Munnich
Director, State and Local Policy Program,
Hubert H. Humphrey Institute of Public Affairs, University of Minnesota

OVERVIEW

MR. MUNNICH: Thanks a lot. Tom. Could I ask the panelists to come up in front? Before we begin the panel presentations I wanted to explain some of the thinking behind this conference. You may have figured out that there are a couple of purposes to the conference, representing interests of different groups involved and how to make it a useful conference.

First of all, it is a policy conference. It builds upon the work that Tom Horan and others at George Mason University have been involved with in the last two years first at Asilomar and then at Diamond Bar. This is a continuation of that dialogue.

Secondly, it is a research symposium. You should have all received up a copy of the papers that were prepared for this conference. Twenty-three papers were prepared. Some of those were short papers, five pages, and some were full papers. We intend to draw upon these papers for the proceedings that will come out later.

There are two parts of the program where papers will be presented. During the next two panels we will be presenting selected papers by authors in the four major areas that will be the categories for our breakout groups - new strategies and technologies, energy and environmental implications, institutional issues and societal implications. You will see that we have selected one presentation for each of the, panel topics.

There will be overlap between these areas; however, we have selected authors who could focus primarily on the topics. In addition to these breakout sessions, we have created an opportunity to hear from and discuss the papers by other authors as well. There will be an authors' roundtable this evening at eight o'clock, moderated by Candace Campbell, a fellow at the Humphrey Institute. At the roundtable, we will have presentations and discussions by the other authors.

Tom asked if I would do a brief overview of the papers. It is difficult given the amount of information in these papers, but I will try to briefly identify what some of the topics are. This is not a substitute for A, reading the papers, or B, attending the authors' roundtable.

In the area of new strategies and technologies Bob Behnke's paper talks about a smart community system a user-friendly, taxpayer-friendly and environmental-friendly way to reduce traffic congestion, gasoline consumption and air pollution and to increase business employment, education, recreation and other opportunities.

Patrick DeCorla-Souza identifies a least cost approach for comparing IVHS, land use, management and multi-modal infrastructure alternatives in order to comply with ISTEA and the Clean Air Act Amendments.

Cathleen Santeiu identifies some near-term applications of radio frequency identification technology in the areas of electronic toll and traffic management, commercial vehicle operations and automatic equipment, identification suggesting that these would favorably impact on environmental aspects of providing more efficient, productive and safe transportation systems.

Sally Spadaro has prepared a paper on intelligent transit information systems that addresses three concepts which bundle intelligent technologies for the purpose of improving transit through transit information systems. Ellen Williams in her paper on high-technology transportation and the information highway, a global market strategy for the U.S., introduces some of the issues related to information infrastructure as it relates to IVHS and the potential for improving the environment.

Allen Greenberg has provided a paper on intelligent vehicle highway systems and bicycling. His paper examines direct IVHS applications for bicycling. other applications that will affect bicycling, and assesses the impact of major proposed IVHS technology projects on the bicycling environment.

In the second category of energy and environment impacts, Monty Hempel talks about integrating goals of air quality, energy conservation, mobility and access in intelligent transportation policy. Jin-Ru Yen, Hani Mahmassani and Robert Herman's paper addresses the energy consumption implications of telecommuting and predict results or potential savings in three Texas cities, Austin, Dallas and Houston.

Simon Washington and Randall Guensler examine carbon monoxide impacts of automatic vehicle identification tolling operations. Matthew Barth on evaluates the impact of IVHS on vehicle emissions using a modal emissions model and, in particular, builds acceleration and deceleration into the model. Finally, in that general category Cheryl Little and Jean Wooster have provided an informative paper that actually identifies operational tests that have an environmental component and they assess the evaluation potential of those projects. This includes international, as well as U.S. operational tests.

In the last two areas of social, economic and institutional issues we have a paper by Barbara Kanninen which presents the economics of IVHS in a very understandable form for non-economists and suggests some of the implications for smart cars, smart streets and smart transit.

Peter Roudebush and Harry Matthews discuss intelligent transportation systems, building consent for post-Cold War transportation initiatives, and appropriate for D-day, have gone back to World War II to trace the changes since that time. Dave Van Hattum and I have prepared a paper on IVHS and public participation, some challenges, opportunities and new models for cooperation.

Philip Winters and Amy Polk examine the need for mutual cooperation between transportation demand management representatives and those involved in IVHS. Finally, Lane Swauger examines integrating IVHS technologies with the ISTEA management systems.

There is a wealth of information in these papers. Beyond this conference, there will be opportunities to use this information as we move forward. Again, I encourage you to come to the authors' roundtable this evening at eight o'clock to discuss these papers further.

Our first presenter today is a person who is well known in the area of transportation and the environment. Daniel Sperling is Director of the Institute of Transportation Studies at the University of California, Davis. He is a professor with joint appointments in the Departments of Civil, Environmental Engineering and Environmental Studies and has responsibilities for transportation planning and policy analysis, energy and environmental planning, clean car technology and transportation in developing areas. He has a new book that will be published in the near future, which I am sure he will mention. We appreciate the fact that he was able to take the time to prepare a paper for our conference in the midst of finishing this book.

Dan has a bachelor's of science from Cornell University, an MS and PHD from the University of California, Berkeley in the area of transportation engineering.

INTELLIGENT AND ENVIRONMENTALLY-SENSIBLE TRANSPORTATION SYSTEM: AN ALTERNATIVE VISION

Daniel Sperling
Institute of Transportation Studies
University of California, Davis
and
Michael Replogle
Environmental Defense Fund

INTRODUCTION

A recent US DOT plan guiding IVHS research correctly notes that, "Over the next 20 years, a national IVHS program could have a greater societal impact than even the Interstate Highway System." But what will those impacts be? What could they be?

The primary thrust of current IVHS initiatives is to accommodate more vehicles more safely using existing roadspace. The principal focus is on two sets of technologies: 1) real-time information to manage traffic flows better; and 2) automated controls to pack vehicles closer together. A variety of other applications are also being pursued, including transit and goods movement, but are receiving much less attention and government resources. The benefits of current IVHS initiatives are coming under increasing scrutiny. It appears unlikely that deployment of IVHS technologies, other than automated vehicle controls, will lead to major congestion reductions or road capacity expansions (e.g., Hall, 1993; Al-Deek et al, 1989). Highway automation could provide large capacity improvements, but perhaps at a huge economic, environmental, and social cost (Burwell, 1993; Gordon, 1992; Johnston and Ceerla, 1994).

The current thrust of IVHS activities, as indicated above, has its historical origins in the highway engineering community; it is described in detail in the 1993 Draft National Program Plan for IVHS prepared by IVHS AMERICA. One might extrapolate these unfolding IVHS initiatives into the future and treat them as one potential IVHS scenario. It is a scenario that could be described as a pragmatic attempt to guide the development and deployment of information and control technologies or, less charitably, as a reductionist engineering approach to the problem of congestion and safety.

An alternative IVHS vision is proposed here. The overarching goal inspiring this vision is increased accessibility -- not mobility; that is, improved access to goods and services, but with little or no increase in vehicle travel. Three complementary goals, suppressed or ignored in current IVHS activities, are also fundamental to this alternative vision: greater consideration of the less privileged, enhanced environmental quality, and community liability.

Pursuit of these goals would lead to a very different transportation future than in the first scenario. Many of the same IVHS products would be commercialized and promoted in both scenarios, with the difference being that in this second scenarios government more actively supports products and activities that benefit lower income classes and the environment. Government marshals its R&D resources, infrastructure investments, and rulemaking authority in such a way that goals of accessibility, equity, and environmental quality dominate the design of the overall system architecture. The many effects of IVHS technologies on travel behavior, land use patterns, vehicle acquisition decisions of households and businesses, and corporate logistical and facility location decisions are treated as primary impacts. The power of IVHS technologies to transform the urban and social landscape, similar to that of the Interstate Highway System, is acknowledged and harnessed.

TOWARD A WIDER RANGE OF TECHNOLOGIES

This alternative vision implies a very different future. One major difference is that a wider range of technologies are envisioned, as suggested below. They include technologies that have been mostly ignored by IVHS proponents. such as smart teleshopping, neighborhood electric vehicles, electronic speed controls, and emissions monitoring devices, as well as others, such as smart paratransit, that are under the current IVHS umbrella, but not receiving high priority.

Shopping through interactive television and other smart information systems might halt the trend toward longer shopping trips to regional warehouse stores. (Facilitating the use o more and better information for goods movement and inventory management by smaller businesses would also offset the trend toward large warehouse stores and long shopping trips.)

Neighborhood electric vehicles, combined with other initiatives discussed below, can be an attractive option for maintaining (or even increasing) accessibility and mobility. Older and less physically-capable people would especially benefit, thanks to the greater ease of driving and the ease of incorporating semi-automated driver-assists into low-speed vehicles. These driver aids would include enhanced collision avoidance, smart cruise control, and assisted steering. Recent market research on vehicle purchase desires in California suggests that a sizable number of households would purchase a small neighborhood car (Kurani et al, 1994; Sperling, 1994).

Electronic speed controls can be used on a variety of roads to provide a variety of benefits. They can be used on residential and low volume roads to increase overall safety and enhance the attractiveness of non-motorized travel and small neighborhood vehicles; on arterials to smooth flows and thereby reduce emissions from gasoline-powered vehicles (and in a manner that enhances neighborhood car safety); and on freeways to reduce speed differentials to improve safety and reduce emissions. Provisions could be made for manual overrides in emergencies and for emergency vehicles such as ambulances, tire engines, and police cars.

Smart paratransit, whereby real-time information is used to connect commercial providers and subscribed rideshare vehicles with travelers. may be the single best opportunity for substantial reductions in vehicle use. Accordingly, it would be given very high priority in this scenario.

TECHNOLOGY AS A CATALYST FOR CHANGE

A second major feature of this alternative vision is the identification and promotion of technologies that could be catalysts for more far reaching and positive changes. The neighborhood electric vehicle is one example. By presenting a viable alternative to the full-size car, these small and low-speed vehicles could be the catalyst for renewed local emphasis on strengthened neighborhood centers and non-motorized travel. Their development and initial deployment might set in motion a series of events that transform communities and road infrastructure.

Another example is the use of IVHS as the enabling technology for more equitable and efficient highway user charges. Better pricing is necessary for the long-term efficient management of our surface transportation system and attainment of healthy air quality in major cities.

LINKING TECHNOLOGY AND DEMAND MANAGEMENT

A third feature of this environmental scenario is a tight linkage of technology deployment with demand-side initiatives in a deliberate attempt to create synergies. The benefits for both technology initiatives and demand-side initiatives will be much greater when paired together than when pursued in isolation. For instance, efforts to price roadspace are unsuccessful because of strong political opposition and inelastic responses by motorists -- for the fundamental reason that drivers see few alternatives to driving. The new fees are seen as punishment, not as incentives to change. If road pricing were introduced as a package with new service and vehicle options, such as smart paratransit and electric vehicles. and used to subsidize those services and products, as well as offset existing taxes, then drivers would more willingly accept road pricing and more quickly embrace the new services and products. Similarly, pairing technology mandates (such as a requirement for zero emission vehicles) with fees on

dirtier cars and rebates for cleaner-burning cars would be far more effective than adopting ZEV mandates or "feebates" in isolation.

SOCIAL EQUITY

This emphasis on social equity is also an important feature of this scenario. Rather than exacerbating the chasm between social and economic classes, it aims to close them by providing high levels of accessibility, not only to the well-to-do, but also poorer people. Instead of IVHS benefits accruing to affluent drivers in the form of expensive safety, navigation, and control devices, the emphasis would be on improved accessibility for all.

SOCIAL COST PRICING

Attention to distributional effects does not, however, imply naivete about the capitalist nature of the economy. the highest priority needs to be given to full social cost pricing. This is a fifth feature of this scenario. The purchase and use of vehicles must be priced to account for the large unpaid social costs associated with motor vehicle use. Doing so, we note, does not necessarily place a larger burden on the poor (Cameron, 1994). In any case, the unpaid costs do not accrue evenly across vehicles, fuels and drivers. The unpaid costs may be near zero in some situations, such as uncongested, unpolluted areas, and huge in others, such as peak times in polluted downtowns. IVHS technologies can and should be used to create clever pricing strategies to target those trips and vehicles that are most costly -- clever in the sense of being politically acceptable and not overly compromising equity goals. Examples include fees on polluting cars with rebates for zero emission and neighborhood electric vehicles; road pricing on congested roadways; pricing revenues used to cross-subsidize various smart paratransit operations; and pay-offs to local residents that have their streets priced or restricted in other ways.

CONCLUSION

Most of the current IVHS services and products will probably lead to large new markets for a wide variety of companies in communications, automotive manufacture, electronics and other high-technology industries. We ask two questions, though: 1) Will those IVHS technologies provide large enough social benefits to justify large government subsidies and support? 2) Is government being assertive enough in guiding technology development and deployment toward the public interest? We think no, in both cases. We suggest a new vision of IVHS policy and investments that embraces social goals of environmental quality, transportation access for all, and urban livability. If public funds and public agencies are to continue playing a prominent role, as they should given the large public presence in the transportation system, then a stronger social vision needs to be articulated and pursued. Expanding highway capacity and creating a market for private business is insufficient justification. A more appropriate and desirable IVHS vision is one premised on increased accessibility to goods and services without increased vehicle travel, greater consideration of the less privileged, enhanced environmental quality, and more livable communities.

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MR. MUNNICH: Thank you, Dan.

Our next speaker is Michael Replogle. Michael has been codirector of the Environmental Defense Fund's Transportation Project since 1992. He is responsible for EDF efforts to promote effective regional enforcement of the Clean Air Act and ISTEA transportation reforms in major metropolitan areas. From 1982 to 1992, Michael was transportation coordinator for the Montgomery County, Maryland Planning Department. He served as a part-time consultant to the Federal Highway Administration and World Bank on non-motorized transportation planning methods and sustainable transportation strategies for development.

He holds an MSE and BSE cum laude in civil and urban engineering and a BA cum laude in sociology, all from the University of Pennsylvania.

INTELLIGENT TRANSPORTATION SYSTEMS FOR SUSTAINABLE COMMUNITIES

Michael Replogle Environmental Defense Fund

EXECUTIVE SUMMARY

"Intelligent Vehicle and Highway Systems" (IVHS) and "Advanced Transport Telematics" are the names which have been used in America and Europe, respectively, to describe the application of information, communications, data acquisition, and control system technologies in surface transportation. These range from mundane traffic advisory message signs on freeways and transit passenger information systems to visionary automated highways where computer-controlled cars might tailgate a few feet apart at 100 mph or more.

IVHS technologies could reshape our communities and societies in far-reaching ways over the next several decades, affecting our lifestyles, environment. economic structure, and social equity nearly as much as the automobile has over past decades. The fundamental architecture and vision of IVHS established in the mid-1990s may serve as a foundation for a technology-driven transformation with considerable consequences. We must ensure that these technologies are harnessed to serve our long-term social, economic, and environmental goals. This will require much broader public participation in IVHS policy making, the establishment of clearer performance objectives and measures for transportation management systems to guide IVHS deployment, and broad-based assessment of the social and environmental impacts of IVHS.

This paper discusses efforts to define the vision and future of these technologies. IVHS will help support more sustainable transportation system development only if it is redefined as part of a broader vision. Recasting IVHS in the multi-modal framework of "Intelligent Transportation Systems" (ITS) -- as has been recently proposed by the Coordinating Council of IVHS AMERICA, a US Department of Transportation (DOT) advisory group -- is symbolic of the beginning of this redefinition process. Alternative visions of IVHS/ITS should be explored with vigor as part of the IVHS architecture development process, which is working to establish national system standards over the next two years. A premature forced consensus on the vision of IVHS/ITS will lay the foundation for long-term conflict rather than cooperation. It is in the interests of industry, transportation interests, the environmental community, and society at large to seek out a win-win vision for IVHS/ITS that meets shared objectives and goals.

If IVHS/ITS is to serve the goals of sustainable communities and transportation, what should be the requirements for its system architecture and its functions? The answer lies not in the selection of one or several isolated "user services", but in the development and deployment of appropriate bundles of technology to ensure that IVHS/ITS can help to manage the growth and patterns of travel demand while improving the efficiency and performance of transportation systems. The most promising elements of IVH/SITS for meeting these objective are:

- smart public transportation, which would allow bus drivers to override traffic signals to speed up bus travel and permit people waiting at a bus stop or at home to know instantly when the next bus is coming, and to feel and be safe when using transit.
- smart paratransit systems to arrange for inexpensive share-ride taxis and to assemble carpools and vanpools on a day-to-day or instant basis.
- smart goods movement systems to help firms arrange for lower cost and less resource-intensive transportation of goods using intermodal systems, improved manufacturing logistics to reduce the need for long-distance shippin g, and improved information, communications, and delivery services to help individuals purchase goods from home or local stores.

- the automated collection of parking and road user fees to reduce taxpayer subsidies to driving and allow market-based pricing of scarce highway capacity during rush hours, with rebates of surplus revenues to all residents to boost equity. These pricing systems could complement or support smog fees that charge more for dirtier vehicles and reduce the cost of using clean modes of travel.
- limiting vehicle speed and acceleration rates on individual roads and in sensitive areas electronically to slow down and "calm" traffic on low-volume residential streets and in commercial areas where pedestrians, bicycles, and transit have priority, to smooth traffic flow on arterial roads with computer-synchronized traffic signals, to reduce emissions and safety problems on high speed expressways caused by speeders. and to reduce top vehicle speeds automatically when icing and fog or accident tie-ups occur.

Such ITS strategies could expand the market potential for small, light weight, neighborhood vehicles suitable for short non-freeway travel. Whether propelled by batteries, small engines, supercapacitors, flywheels. human power, or a combination, these vehicles would allow individuals and firms the opportunity to better tailor the vehicle chosen for a particular trip to their end use requirements. Such ITS could help complement a needed realignment of transportation subsidies and investments, the reallocation of street space to restore opportunities for walking, bicycling, and rapid transit, and smart land use policies that encourage reinvestment in cities and inner ring suburban centers where managed growth will help solve rather than exacerbate pressing traffic and social problems.

BACKGROUND

IVHS/ITS promises to help in the switch from military to civilian production and could be a major source of long-term economic growth and increased productivity. Projected IVHS/ITS deployment costs over the next 20 years in America alone are expected to be about \$40 billion in public infrastructure and \$170 billion in private spending. The promise of an even larger future global market for IVHS/ITS has US automobile and electronics firms in heated competition with the Europeans and Japanese to gain a lead in developing these technologies. This accounts for the strong bipartisan support in Congress and from the Bush and Clinton Administrations for increased US Department of Transportation IVHS research, which will reach almost \$300 million annually in FY 1995. A recent US DOT plan guiding IVHS research notes that, "Over the next 20 years, a national IVHS program could have a greater societal impact than even the Interstate Highway System."

Appropriately directed, these technologies could undo much of the damage caused by short-sighted transportation policies of the past several decades, improving air quality and community livability and improving our ability to finance needed transportation and community infrastructure and services while sharply reducing traffic congestion, energy use, and the toll of traffic accidents. But as it has been developed to date, IVHS threatens to repeat the mistakes of the past, increasing suburban sprawl, air pollution, and dependence on automobiles and imported oil, while further reducing our freedom to walk and bicycle in our communities.

There is a danger that IVHS/ITS will be used only to buy another couple decades for unsustainable transportation and land use policies. Instead we could use this opportunity to begin the long-term transition away from unsustainable policies. Smart technologies, like cleaner motor vehicle technologies, can help us, but must be harnessed to serve environmental and energy requirements and a vision of more sustainable and livable communities. Sustainable transportation requires adoption of a new paradigm emphasizing multimodal accessibility and the reintegration of communities, not the blind pursuit of expanded mobility.

IVHS PROGRAM PLANNING IN AMERICA

The direction for IVHS developed in the late 1980s and early 1990s has been shaped by visionary traffic engineers, hardware manufacturing firms, and traditional highway user interests. These groups played a central role in organizing the federal advisory committee, IVHS AMERICA, which has guided IVHS policy and program development. While making worthy contributions in advancing both IVHS technologies and Congressional support for them, IVHS AMERICA and the US DOT IVHS program now face a considerable challenge in expanding public understanding and support for the program.

IVHS Strategic Plan

The *Strategic Plan for IVHS in the United States*, issued in May, 1992, acknowledged new policy orientations related to the Clean Air Act Amendments of 1990 and the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) but fell far short of embracing these or the participative process goals of these acts. As a vision of the future, the *Strategic Plan* reflected the perspectives of those involved in its creation, who were largely bright, affluent, white, male, suburban-dwelling professionals. Their vision for IVHS has reflected overwhelming optimism in technology to solve problems while often downplaying the potential for major secondary social, environmental, and economic impacts. This vision of IVHS has emphasized strategies for squeezing more cars and trucks onto existing highways and making motor vehicle use more attractive, rather than favoring strategies to manage growing motor vehicle travel demand. It has focused less attention on strategies that could reduce the current forced dependence on automobiles so common in American suburbs and edge cities. It has focused little on the needs of children, the poor, or the elderly. Indeed, IVHS has been set on a possible collision course with the Clean Air Act in America's more polluted cities. Major concerns are being raised about IVHS by environmentalists, traffic safety advocates, representatives of inner city interests, bicycle and pedestrian interest groups, and others.

National IVHS Program Plan

Since mid- 1993, US DOT has been developing a new *National Program Plan for IVHS*. This effort is being undertaken with an intent to broaden outreach to new constituencies and to address emerging issues regarding transportation system sustainability. A May 1994 draft of this Plan shows significant improvement over an earlier version circulated for comment in the fall of 1993, and will be subject to a broader public review process. US DOT has begun to address vital issues of program support, assessment, and public involvement, but much further effort will be necessary to evoke and evaluate a range of alternative visions and scenarios for IVHWTS development which reflect the perspectives and values of those not well represented in IVHS AMERICA.

A broad-based technology assessment will be vital critical to evaluating the systemic impacts of interlinked bundles of IVHS/ITS technologies. The relationship of transportation demand management (TDM) to even the latest draft *IVHS Program Plan* remains similar to that of icing on the cake, with TDM is identified as a "user service bundle," rather than a metastrategy which infuses the design of the overall system architecture. This almost guarantees that the resulting IVHS/ITS program will, with few exceptions, ineffectively integrate demand management into what many continue to see as its primary task of increasing transportation capacity and vehicle throughput.

While the latest draft *iVHS Program Plan* takes a less reductionist engineering approach to the problem of assessing costs, benefits, and impacts than the earlier draft, there is still too little consideration of the potential interaction of "user service bundles." Interaction of IVHS/ITS technologies with broader social and economic forces and trends is given little thought. The latest Plan does begin to discuss how these technologies could be used in a goal-directed fashion to help implement the Clean Air Act and develop effective ISTEA-mandated management systems, but this needs to be expanded. Much greater attention needs to be given to the many potential effects of IVHS/ITS technologies on travel behavior. land use patterns, vehicle acquisition decisions of households and businesses, and corporate planning related to logistics and facility location. These are not minor secondary impacts which can be ignored. Indeed, they must be carefully evaluated in a holistic analytic framework which considers alternative deployment scenarios for alternative bundles of IVHS/ITS technologies. The latest Plan draft recognizes the need for scenario evaluation, but needs to emphasize a greater involvement of social scientists and the broad public in this work. These activities are not suitable for conventional engineering analysis, but require the perspectives of anthropology, sociology, systems analysis, and economics.

Expanding Participation for a New Vision

Recent positive steps to broaden participation in the IVHS program have yet to fully overcome the effects of past neglect for the concerns of environmentalists, transportation and land use reform activists, inner city interests, and other groups in IVHS planning The continuing legacy of distrust and opposition to IVHS program deployment

and funding from these communities of interest will be overcome only by further expanding participation of non-traditional transportation and community interest groups and by making environmental, social equity. and community livability goals central elements in IVHS/ITS program planning, assessment, and management.

The vision and architecture of IVHS in America is undergoing an important process of redefinition and reappraisal in the mid-1990s. This is a natural outgrowth of significant transportation policy reforms set in motion by the forces which helped craft and win passage of the Clean Air Act Amendments of 1990, the Inter-modal Surface Transportation Efficiency Act (ISTEA) of 1991, the Energy Policy Act of 1992, and the U.S. government's commitment to reduce CO2 emissions to 1990 levels by 2000 as part of the National Climate Action Plan and Rio Accord implementation.

Recognizing the need for reform, US DOT has begun to change the focus of its IVHS/ITS program. A management reorganization has put a spotlight on the need for a stronger intermodal and multi-modal program focus: The federal advisory committee used by US DOT is contemplating a change in its name from IVHS to ITS -- Intelligent *Transportation* Systems. Greater public input is being sought to help define the vision and system architecture for IVHS/ITS. Environmentalists, transportation policy makers, and leaders of the IVHS community are beginning to explore common ground. In many cases they are finding broad opportunities for successful cooperation focused on a refined win-win vision for ITS.

US DOT's progress in moving the IVHS program towards a broader ITS framework and in placing greater emphasis on the environmental and societal impacts of these and other transportation technologies and policies is encouraging. However, this needs to affect agency policy-making regulatory actions, program coordination, and funding in a more systematic fashion. US DOT Funding now dedicated solely to support involvement of traditional transportation interest groups must be similarly targeted to support involvement by non-traditional constituiencies and non-governmental organizations (NGOs) in transportation planning and policy making, especially at the metropolitan and national levels.

For example, resources have recently been increased by US DOT and EPA for long-term improvement of transportation models and data collection, essential to measuring the effects of IVHS/ITS deployment on air quality and congestion. Still, short-term reforms of these models and data systems at the local, metropolitan, and state level too often languish because of inadequate regulatory requirements, guidance, incentives, technical support, and public oversight. NGOs representing broad public interests are frequently denied ready access to these taxpayer-funded data and analysis systems, which are being manipulated and abused to resist ISTEA and CAA reform initiatives. Changes in the right direction are beginning to occur, but too slowly to provide the information which may be needed to ensure that IVHS/ITS will not violate Clean Air Act requirements in the areas with serious air quality problems which could benefit most from a reoriented IVHS/ITS program. Bad models, inadequate data, and resistance to public oversight and public participation make litigation, rather than cooperation, the most likely future course for metropolitan transportation planning in many regions, putting IVHS/ITS at risk.

A WIN-WIN VISION FOR IVHS/ITS

If IVHS/ITS is to ultimately give us not just smart cars and smart highways, but smart communities, US DOT's research program needs a new vision to ensure that it will boost environmental sustainability and community livability while promoting economic growth, defense conversion, and US competitiveness. What might some key elements of this new vision for IVHS/ITS include? What strategies might merit greater or less emphasis for taxpayer-supported investment in R&D?

Electronic Road and Parking Pricing

IVHS/ITS could worsen congestion and pollution problems in the long-run if it expands highway capacity without first applying its potential for automated road pricing. However, IVHS/ITS could provide the enabling technology for automated high-speed electronic toll collection systems which could help reduce traffic congestion and manage the increased demand for travel demand stimulated by other IVHS/ITS technologies. This could be the

most important breakthrough in surface transportation in recent decades, but has been put on a slow track for IVHWTS development. Electronic highway toll systems have been successfully pioneered in Norway, Sweden, Singapore, and several American communities. Major American firms, such as AT&T are poised to provide new "smart cards" which could be the foundation of new approaches to transportation user fees.

The costs and delays associated with toll collection have throughout this century encouraged us to give away free use of our highways rather than charging users directly and charging more in times of peak demand, as is done for telephones, airlines, and electricity. By not paying the full costs for transportation, we have been encouraged to over-consume travel, especially by automobile, leading to growing congestion, delay, oil imports, and pollution. However, this will not be achieved unless new approaches to selling road pricing are developed, which will require as much emphasis to human and marketing factors as to engineering, such as "Smart Express Lanes" (see Box later in this paper) and rebates of road pricing revenues to a region's residents through direct payments or tax reductions. Such approaches need to be more fully developed and evaluated as part of IVHS/ITS planning.

Another IVHS/ITS technology, Automatic Vehicle Identification (AVI), can be used to track the location of trucks and cars and for automatic payment of tolls without stopping at toll booths. While this eliminates the congestion and delay associated with charging tolls, it raises questions about privacy which must be addressed, since they may make it acceptable only for commercial vehicles. The early committment to AVI technologies for road pricing related IVHS operational tests may lead to missed strategic opportunities to use IVHS/ITS as the enabling technology for more equitable highway user charges, which are necessary for the long-term efficient management of our surface transportation system and attainment of healthy air quality in major cities. What are public attitudes towards AVI and road pricing? How aware is the public of current large hidden subsidies which encourage overuse of the automobile and the costs of these subsidies to individuals and businesses? How could AVI or electronic smart card pricing systems best be implemented to minimize public opposition? These key questions should be evaluated in the IVHS/ITS program to help move forward with positive environmental benefits rather than simply promoting further dependence on subsidized private motor vehicle travel.

IVHS/ITS and Transit

The current IVHS/ITS research program is pursuing some technologies which will help to reduce automobile dependence, although funding priorities need to be re-examined. Advanced public transportation systems have received a relatively small share of the IVHS/ITS research budget to demonstrate technologies in which the US lags far behind the Europeans and Japanese. For example, real-time transit passenger information systems allow travelers to know from their home or from a bus stop exactly when the next bus will come. reducing wasted waiting time and boosting the attractiveness of transit. Many elements of such systems have been in use in France, Japan, and elsewhere for over a decade. Another example is systems for real-time transit communications and operations management. These track transit vehicles and enable quick responses to delays or problems and enable bus drivers to override computerized traffic signals to reduce delays experienced by transit, boosting both speed and schedule reliability. Such systems have been widely developed abroad and were beginning to come into more widespread use in the US in the late 1970s but fell victim to transit funding cutbacks of the 1980s. The IVHS Program Plan should recognize and draw on this experience and propose these elements for early deployment as "low hanging fruit."

Other current IVHWTS program elements which offer promise include development of new premium dialaride services and new travel information services from homes, workplaces, and public kiosks. The next wave of wireless communications devices could complement these by enabling instant carpool matching systems. The IVHS Program Plan begins to address these concepts, but will need to do far more to consider how these might interact with new multi-media communication and information system developments now being led by private sector initiative.

Automatic Speed Limitation

The IVHS research program has focused mostly on engineering solutions to increase both highway capacity and the attractiveness of the automobile. One major area of research is on devising automated collusion avoidance

systems and automated highways to squeeze more cars into the same road space at higher speeds, potentially doubling or tripling the amount of traffic without widening highways. Congress has put a high priority on automated roadway technologies, seeking a demonstration of the concept by 1997 and earmarking funds for this purpose. However, major questions remain about the consequences of inevitable computer failures, where all this traffic will go when it leaves automated highways and is dumped onto non-automated urban and suburban streets, and the environmental effects of a sharp increase in long-distance driving.

The IVHS/ITS national program plan needs to undertake a critical appraisal of the near and mid-term goals for the Automated Highway System program, asking the right questions about its potentially devastating effects on cities, on air quality, and on energy and land use. A more practical early deployment of AHS technologies might be to mandate that motor vehicle manufacturers install the capability for local-option speed limitation controls on vehicles.

IVHS/ITS could develop technology that automatically limits cars and trucks to the posted speed limit on streets and highways and prevents red light running, resulting in fewer accidents and traffic deaths, less aggressive driving, smoother traffic flow, reduced air pollution, and more livable communities. In short, a part of a "green vision of law and order." This technology could be used to help ensure that arterial traffic moves at a speed synchronized with computerized traffic signal progressions, rather than in the "hurry up and wait" pattern, with its associated high air pollution emissions related to rapid vehicle acceleration and deceleration, common in US cities and suburbs. It could reduce the emissions associated with over 55 mph freeway driving. It could accomplish "electronic traffic calming," slowing traffic on residential and commercial streets to restore options for safe walking and bicycling, reducing vehicle miles of travel, the number of motor vehicle trip starts, and emissions of VOC, CO, PM-10, and NOx.

This could produce tradable emission credits for local communities that decide to implement these strategies, supporting local economic development opportunities in polluted regions. Such technologies could expand the potential market for safe and attractive use of small, lightweight, non-polluting, efficient electric neighborhood vehicles for use on all but the largest high speed highways, dramatically cutting US dependence on imported oil and reducing greenhouse gas emissions. However, the concept of vehicle speed limitation is not now a part of the *IVHS Program Plan*, which has limited itself to ideas such as "reminding motorists that they are exceeding the speed limit,"

Smart Drivers or Smart Communities?

A major thrust of the current IVHS/ITS program is to give information on traffic congestion as it occurs to drivers who invest in special in-vehicle communications and computer display equipment, enabling them to take alternative routes. So long as only a few drivers have these expensive systems, they will likely save time and reduce traffic problems. If most drivers have such systems, however, the benefits will tend to diminish as alternative routes themselves become congested. In some circumstances, research has suggested that these systems could lead to increased rather than reduced congestion. The IVHS/ITS national program should work to improve understanding of these potential complex system questions.

In-vehicle travel information may be useful and may find a ready market among drivers who can afford it. However, public investment might be better directed at development of new Smart Community information systems to enable everyone to meet their daily activity needs with less need to travel and less automobile dependence. For example, most of us now use a "hunt and gather" approach to errand running -- driving around to different shopping centers and stores, often without knowing which shop has the goods or services desired. A Smart Community information system would provide an "expert system" to exploit the new information superhighways and identify where and how you can get desired goods and services with the least amount of time, cost, and hassle. This would expand opportunities to order goods for home delivery, eliminating the need to travel or the need to carry loads if shopping in-person. In other cases, these systems would enable you to find out which stores have the goods you want in stock, at what price, with expert system help in suggesting the most efficient itinerary for running errands, given your expressed intentions, constraints, and usual preferences. However, there needs to be a careful consideration of the potential effects of such systems on the retail sector and community structure. System designs that can support, rather than undermine neighborhood shopping opportunities should be explored.

CONCLUSION

Unless demand management strategies are tightly bundled in with highway systems, these systems will face opposition in many communities in America as the air quality and community livability. Without vision and foresight, IVHS/ITS will public's tax dollars, a barrier to healthy air quality, a contributor to more rapid global bills, a source of ongoing legal and political conflict, and yet another costly mistake redirection, however, IVHS/ITS could be the most important enabling technology dr progress in American transportation, winning for our citizens sustainable high wage jo livable communities, and a healthy environment. Hopefully, the environmental commu will find the win-win strategies and till together common ground to build sustainable sustainable economy.

CAN SMART EXPRESS LANES MAKE ROAD PRICING ACCEPTABLE?:

Road pricing has for years been rejected as technically impractical and politically unacceptable, although virtually every transport economist has advocated the concept as the single most important innovation in surface transportation which could increase system efficiency and performance. IVHS/ITS removes the technical barriers to road pricing. Now the task is to devise a politically sound implementation strategy.

Acceptance of road pricing will require public education, marketing, and a gradualist approach. The most promising strategy may be to use non-contact electronic smart debit cards for payment of user fees for transit, parking, and high speed automated toll lanes. "Smart Express Lanes" could represent a pragmatic strategy for the gradual conversion of our existing, inefficiently managed road system to a more efficient, market-oriented management system. This approach would guarantee congestion-free travel for those willing to pay to use Smart Express Lanes, offer others the option of using free but more congested lanes, and distribute to all residents the surplus revenues from the system, avoiding the creation of new taxes. Everyone is set up to get what appears to be something for almost nothing.

At first, only existing toll roads and a single lane of congested multi-lane interstate highways in a metropolitan area might be converted to Smart Express Lanes. Smart card readers would be offered for free installation in all vehicles at the owners' option at the time of annual vehicle safety and emissions inspection and would be mandatory in all new vehicles sold in the region. Smart cards usable in the readers would be anonymous and could be exchanged, purchased, or have value added to them at banks, gas stations, and selected convenience stores. Low energy sensors planted at frequent intervals in the Smart Express Lanes would interact electronically with the smart debit cards at full highway speeds -- eliminating toil booths -- deducting value from the card for each mile driven. Video cameras would record the license plates of those using the lanes without proper payment, leading to a ticket by mail. Smart cards could be used also for automated parking charge payment, with low cost entry-way sensors used to convert ubiquitous uncontrolled suburban parking lots to a price-mediated system.

The periodic rebate of the large revenues from the Smart Express Lanes to all residents in the metropolitan area, after deducting system costs, would avoid new taxs, promote more equitable income distribution, and create a constituency favorable to increasing the lane-miles of smart roadways and the price of using them. A bond issue that pays for installation of the system could finance issuance of rebate checks in advance to residents when the pricing system begins operation to build public support.

PRIVATE SECTOR ASPECTS TO ITS AND THE ENVIRONMENT

Stephen Lockwood Vice President, Parsons Brinkerhoff

MR. LOCKWOOD: I would like to start by echoing others and congratulating the sponsors of this excellent forum that I hope will continue in a series over a period of time to bring together this type of group, and there have certainly been many very excellent balanced presentations today. So, I wonder whether I have been asked to be a kind of agent provocateur here in the middle of this balance, a kind of a straw man. I am looking around, and I see that there are perhaps three representatives of a pure, non-consultant private entities here in the room and a number of consultants that are certainly concerned with investment and returns. So, I wonder what I am getting into here, but let us for a moment or I am going to for a moment abandon political correctness and social and environmentally correct attitudes towards IVHS. I would like to associate myself with all the preceding remarks that have been made, and what I want to talk about is really not a grand conception about how the private sector can work hand in hand with the public sector to resolve what are clearly a lot of very thorny and outstanding transportation and environmental issues of the day that have been very much a part of the remarks this morning. I am going to take a more narrow, but I hope realistic commercial focus from a kind of a private perspective, a private perspective, not about markets, about problems in getting returns on risky investments and other realities of capitalism that are probably needed to get IVHS off the ground and to realize the promised benefits. There are disbenefits that have been discussed here today because there are some very serious institutional and environmental issues that in fact are barriers. We need to be careful that we do not smother the golden goose before it begins to quack.

There are some very serious hurdles here to private entities who are potential investors or sponsors who live in a world where they deal with market and technical and competitive uncertainties. There are some very tough institutional environmental issues that are joined within the context of anything that happens within the federal aid program process, and perhaps from at least some private sector perspectives environmental issues, are associated with IVHS are real, but the process of resolving them, seems very fuzzy and unbusinesslike, maybe even irrational. In that regard I would associate myself with Fred Krupp's lunchtime remarks about the problems of the costs and the benefits and the trade-offs as distinct from our desire to impose our own policy objectives on a very new program.

So, I want to talk about IVHS from a private or business perspective as distinct from IVHS as a tool for public policy, having already associated myself with those previous perspectives. A kind of a short quarterly report view and think a little bit about IVHS from the point of view of the business opportunities that have the maximum payoff and the minimum hurdles and that will allow us as a society to capture the benefits, to develop the systems and for those in the private sector to gain a reasonable return on investment.

Of course a number of these hurdles arise straightforwardly from public transportation agency involvement and the use of public funds and the associated environmental process, and a number of these hurdles we typically call public policy.

So, in part, a not unreasonable private sector investment strategy is to try to proceed down some of the lines of IVHS markets as an independent business where feasible and try to couple one's self as much as feasible from the regulatory process.

Certainly from a private perspective a lot of the IVHS environmental dialogue sometimes seems to be a little bit unbalanced because it starts out, or seems to start out sometimes, from an apparent presumption that all IVHS is simply part of the federal aid program with all the voluntary mandates that flow down to states and local government.

Of course, today that kind of IVHS is still very small potatoes. We are talking about a \$300 million federal investment in the IVHS program specifically, maybe a billion dollars a year being invested nationwide, and that is out of an \$80 billion all levels of government investment in transportation, \$1 billion out of eighty, and keep in mind

that that \$80 billion is out of a trillion dollar annual sector expenditure. So, all public investments less than 10 percent in IVHS is some percent of 1 percent.

So let us keep a perspective on the impact of what we are talking about and how long it may take to move to a state of prominence where it is going to be visible to us.

I think another fundamental reality is the private sector has most of the required capital and all the required technology to make any of this happen. So, the question about how the private sector views the public policy dialogue is not an insignificant concern that we who are at least partly in the public sector or who have been in the public sector need to keep in mind.

It certainly appears sometimes from the outside that within the transportation program environmental quality is mandated, regulated and targeted. Mobility is sort of, well, if we can get some of that along the way, that is great.

It seems a bit curious, and it does seem that from the point of view of our economy and its competitiveness that our dialogue often tends to ignore the broad range of direct benefits and especially many of the long-term indirect benefits that repeat throughout the economy from the kinds of investments that we are talking about.

The thesis I want to present is that it is important to recognize that IVHS is a collective noun, that it is not monolithic and that there is a tendency perhaps to group all of IVHS or ITS rhetorically together as being environmentally suspect even in many cases when it is neutral or obviously positive or where the negatives may be very marginal compared to the benefits.

I think this aggregation is important and the IVHS program plan certainly recognizes that in terms of its range of user service presentation and the bundling concept, and obviously within each of these user service and bundling areas are the environmental institutional issues.

It is important to recognize, I think, as part of this disaggregation that various of the IVHS services or activities can be realized through alternative sectoral arrangements. In fact, the public sector is not necessary in all of IVHS and certainly minor in others although it is certainly key in some. So it is important from a private sector perspective to move ahead and perhaps to think about IVHS as a business instead of public policy and to think about how to minimize the delay due to environmental uncertainties. I think disaggregation helps in this regard, and it is quite possible | believe to sort various IVHS applications by apparent environmental benefits and risks. The partnership requirements with the public sector and if you are a private investor it may make sense to focus, as appropriate, on the services within minimum environmental issues.

Certainly from the private sector perspective the benefits are very real. The business opportunities are very real. I do not have time to talk about what we are doing in the transportation sector because it is already substantially foreshadowed and mirrored within many parts of American industry as the manufacturing service sectors reorganize themselves under the impact of improved communications, process engineering, just-in-time logistics and so on. There are IVHS-like things not so labeled going on in the economy substantially out of the view of public policy.

I think a second important realization is that to talk about the benefit side, much less the disbenefit side of IVHS, requires the penetration of new technology into the transportation and guideways systems. This, in turn, requires a lot of new institutional relationships. Remembering that transportation is still the last of our great public service monopolies, except for the post office, and it is by nature conservative, bureaucratic, risk averse and low tech to move it into the IVHS arena is going to require a lot of reorientation within the sector top to bottom on the public side, as well as on the private side.

Reinventing transportation is certainly not too grand a concept when you talk about the need to move towards a management-oriented, real-time-based, customer-sensitive perspective to transportation. That is very different from the tradition in transportation agencies historically, and there are reorientations needed within the public sector, on a public-public partnership basis among levels of government, on the public-private side that I am going to come to and then within the private sector new types of strategic alliances.

There are all sorts of new kinds of institutional relationships that one can talk about. I have time to focus on anything except public-private partnerships for a bit.

Why is the private sector essential? Technology finance market orientation in the public sector needs these to realize virtually all of the kinds of services that we are talking about today. Best available technology, the public sector doesn't have the best available technology. It is not particularly good at applying, witness the recent GAO report on the status of our automatic traffic control systems which are already a generation behind Europe in the US, freeway surveillance and control; we have something less than 10 percent of the nation instrumented at the present time although technologies have been around for 15 or 20 years. The private sector owns and develops the technology. The automotive manufacturing arena certainly can be a very essential part of a lot of what we have been talking about here today, and of course, last but by no means least and perhaps most important, the capital. IVHS AMERICA estimates that 80 percent of the \$200 billion that are going to be needed in the next 20 years are going to come from the private sector. It isn't going to come, if the hurdles are too high.

Now, when we talk about private sector, we need to disaggregate there a little bit, too, it seems to me because there are, of course indirect beneficiaries of private enterprises of all sorts and ourselves as individuals that benefit, but within the programmatic sense there are shippers and carriers and travelers who get involved, and remember that about half of the benefits of IVHS are likely to flow into the freight arena in a dollar sense, and also, there are the direct participants in the program, those who supply products and technology and services. The term "vendor" is used, and it is always used, in the public arena with kind of a sneer, you know, vendors, those are the guys who kind of sneak around. Vendors, these are the people with the technology. These are the people who develop the systems. These are the people who develop and market and sell and service the products that are needed, whether they are fixed or mobile, automotive or not. These are the people who provide services. Those are those kind of vendor people of which we have, unfortunately, only two or three here in the meeting today.

What are the barriers that are faced here? When we started talking within the IVHS program about barriers to partnerships and moving ahead, I think most of us thought that the vendors were sort of technical barriers in the sense that they were legal and institutional issues like liability and antitrust, and these are real issues, no doubt about it, but I think we are increasingly coming to the conclusion that many of the barriers are cultural. The differences between transportation agencies and profit-driven and technology driven institutions on the private side are a completely different source of incentives, a completely different risk/reward feeling. It is very hard to have a dialogue about those things.

The models for public-private participation have been the second place where, in the IVHS community, we have begun to think about how to bridge the gap between sectors. I do not have time this afternoon to do more than touch in passing, but there is a broad range of institutional ways and from a business and contractual and associative fashion the public and private sector can work together. Of course, there is completely public and completely private, but the in betweens are the more interesting. The public sector is an owner, wholesaling, for example, information services that private resellers can turn into a business or conversely a private sector owner of a service or facility leasing or selling something back to government, franchise operations as in some of the new toll roads around the country, consortium-type operations; there are a number of models that are now being looked at that may be appropriate to allow public and private entities to embrace themselves in a new way positive to moving ahead, but I think, also, that in a short-term and strategic sense it makes a lot of sense from a private sector point of view to focus on those areas where the private sector can move ahead substantially independently, and I have a graphic here that suggests a way perhaps to think about it.

Easily identified private benefits and little or positive environmental impacts and little or no public participation.	Maximum public and private benefits, broader mix of benefits with identifiable private stakeholders, clear broad public benefits, and possible
No interest, not much benefit presumably by definition.	Major public benefits and some private opportunities, benefits are substantially public, with substantial public involvement, the environmental risk vary*

Figure 1: Matrix of Private Opportunity and Public Benefit

As you can see, this is a matrix with four cells, and the cells are differentiated by the degree of sort of private opportunity and private benefit going vertical and public benefit going horizontal and then within the cells vertical there is increasing perceived environment risk so that quadrant number one up on the lefthand side are those IVHS services with easily identified private benefits, with little or clearly positive environmental issues and perhaps modest or no public involvement needed, CVO commercial vehicle operations and the automating of the regulatory process, for example, for interstate trucking is a good example of that.

The second quadrant on the upper righthand comer is the maximum, you might say public and private benefits, a broader mix of benefits with identifiable private stakeholders but clearly broad public benefits and possibly negative environmental issues and in this arena partnerships are not necessary but likely, and I have just thrown a couple of examples in, in the upper righthand comer most difficult, of course, the automated highway system, a lot of environmental concerns, but it is potentially a large public and private program.

Navigation and guidance is what N&G means, again, often talked about within the IVHS arena and the subject of many operational tests is something that may or may not require substantial public involvement as distinct from a stand-alone private business and the lower lefthand comer TIS by which I mean traveler information meaning pure information as distinct from navigation and again you know, starting with commercial radio stations it is clear that there may be a business there, and there may be public benefits but it doesn't necessarily require a lot of partnering.

In the lower righthand comer there are services that have major public benefits and some private opportunities in terms of business, and it is a matter of judgment as to the scale, but here freeway surveillance and control, advance traffic control systems, arterial control systems, incident management, these are things where there are some private opportunities but their benefits are substantially public, and there is going to be substantial public involvement, and the environmental risk vary here and my vertical listing was just my guess. The lower lefthand quadrant no interest, not much benefit presumably by definition. So, from a private perspective the most promising opportunities are those where markets are identified, where there are no apparent environmental negatives which is to say minimum business risk where there may be the opportunities for stand-alone private enterprise with only modest partnering or interaction with public transportation agencies and I have mentioned a few of what the examples are here.

So, the bottom line from the private perspective is perhaps it makes sense to push the envelope of privatization as far as possible if we are talking about minimizing delay. For example, this suggests that the IVHS program should be particularly supportive to proposals that originate in the private sector and even those that involve creating private businesses as distinct from the other way around where the programs usually are trying to adapt private sector interest to public policy objectives. Secondly, I think it suggests that the public sector should be

supportive of maximizing private responsibility particularly where environmental issues are not invoked, and there are some things that need to be done that aren't being done along those lines, one of which is not just to test systems which I think we are doing fairly effectively in an increasing volume but, also, to demonstrate markets because of course, a major hurdle to private industry is is there going to be a market; is there a business there; is IVHS a service or a business; where do we draw the line? Market research which is very expensive is something that the government could do to make available to any and all comers.

Finally, it seems to me that we need to continue to press to find new ways to partner, to review the barriers that we have long thought standing in the way and determine which of those are really legal and technical and which are in fact, simply a difference in point of view that might be overcome by more communication. I think in that fashion we may find that there are opportunities to move part of the IVHS program in a disaggregated fashion ahead of those parts which are less environmentally sensitive and gain those benefits while we struggle together on those which are.

I would end with one particular suggestion which I think is perhaps a bit of a detail or a footnote, but I think it is important because where there are serious environmental issues and where partnerships between the public and private sector are important, we need to devise, I believe some new and more reasonable strategies to deal with environmental uncertainties.

To begin with we need to explicitly recognize the uncertainties of the forecasting and analysis which surrounds the whole regulatory process that exists today that we kind of hide under a rug, and we only acknowledge in the technical chambers after such conferences as this one.

At the same time, it seems to me we need to try to more aggressively capitalize on the operating and management characteristics of many IVHS applications that fit right into environmental monitoring technology approaches.

A management approach I believe supplies one way out of the dilemma posed in a regulatory context with hard targets and uncertain tools, and that strategy is built on the concept of operating and monitoring systems in real time towards specific objectives.

That sounds simple, and let me suggest how it might work. In the context of the kind of hard regulatory thresholds, air quality targets, for example, and the usual marginal differences between build and no-build scenarios of say 2 to 3 percent that we then analyze with models that have a plus or minus 20 to 25 percent uncertainty and try to draw reasonable conclusions, instead of trying to make believable the unbelievable, which I think, also, borders on the unprofessional, it seems to me it makes more sense from a private perspective at least to develop an implementation of improvements within a kind of a tuning if you will, a kind of a tuning framework combined with a contractual obligation to manage systems towards the appropriate environmental and transportation objectives.

What does that mouthful mean? It means equipping facilities with the hardware and software that we need as well as contractual agreements to manage them towards the appropriate environmental objectives. Rather than try to forecast the impact on the air quality in the year 2007, we can operate them and tune the systems to achieve the air quality objective. We can go from HOV-2 to -3 to -4 or -4 to -3 to -2, and I think in this general operational perspective it is consistently consistent with what IVHS is all about and if we substitute monitoring and tuning for targeting and forecasting we will be in an environment where the private sector, I think in a much more collaborative way can work towards both providing mobility improvements and environmental improvements at the same time.

Thank you.

MR. MUNNICH: Our final speaker is Barbara Richardson who is a research scientist at the University of Michigan, Transportation Research Institute. She recently rejoined the University of Michigan's Transportation Institute working in the area of societal, institutional and policy issues in both the public and private transportation sectors. She, also, founded Richardson Associates, a consulting firm which she still serves as president.

She has her BA in mathematics at the University of New York at Albany and an FM in civil engineering in the field of transportation, systems analysis at MIT with a PHD at the University of Michigan in sociotechnological planning in the field of transportation policy analysis.

SOCIOECONOMIC ISSUES AND INTELLIGENT TRANSPORTATION SYSTEMS

Barbara C. Richardson The University of Michigan Transportation Research Institute.

INTRODUCTION

The transportation system is an integral part of the societal-economic system of every group of people on earth. It is through transportation that people gain access to the things they need to do to be functioning members of society. While other means of access (e.g., telecommuting, teleconferencing, television shopping) are developing and will become more common in the future, the need for transportation will remain dominant for any planning horizon that we can conceive. To plan a transportation system without explicit inclusion of the societal and economic factors that affect and are affected by transportation would be unwise.

In the United States as we have planned and implemented transportation systems over the last 200 years, precedence has been given to the technological factors of importance. Those rail transit systems that we have are functional; our Interstate Highway System is excellent; and our vehicles compete in the world market. In planning and executing the provision of transportation services, we have focused on the technology and all too often have not addressed the larger social issues. As we laid rail track across the country and built highways that would divide neighborhoods, we did not ask the local people what they thought of these innovations With rare exceptions, the voices of individuals were not heard in the transportation planning process. (Weiner 1992). In the 1960s and 1970s the building of the Interstate Highway System began to be questioned by people who would be most negatively affected by it. Many would lose their homes or their neighborhoods. Their concerns began to be addressed through such forums as the Boston Transportation Planning Review in which citizens participated in the planning process through public meetings. Academics began looking at ways to incorporate societal concerns explicitly in the planning process. (Richardson 1973).

Even with these efforts, major time and cost delays occurred in the completion of the Interstate System. We reached the point of enormous expenditures per mile of construction of roads in our urban areas -- time and expenses that could have been markedly less had major societal and economic issues been addressed early in the process. Not only is it important to address societal and economic issues for what we may consider as altruistic reasons, but it is also important to do so because it is good business. (See Underwood and Streff 1992 for a discussion of the items that need to be considered in evaluating Intelligent Vehicle-Highway System (IVHS) technologies.) It will save time and money in the long run and produce a product that will better serve society. Noting, in 1972, how important it was to address societal issues in their business planning process, the Business Environment Studies component in General Electric noted "Without a proper business response, the societal expectations of today become the political issues of tomorrow, legislated requirements the next day, and litigation the day after." (Wilson 1985)

PURPOSE OF THIS PAPER

The goal of this paper is to raise for discussion the concept that it is more cost-effective and less expensive for both the public and private participants in the Intelligent Transportation Systems community to start planning and implementing intelligent transportation systems with societal and economic issues included in the planning process from the very beginning. There are several objectives that support this goal. These are:

- 1) to explain transportation systems as part of the larger social/economic/political/environmental system.
- to identify many of the societal and economic factors that impact or are impacted by transportation systems;

- 3) to present "forecasts" of several of these factors; and
- to suggest ways of analytically incorporating these factors into the planning process.

METHOD AND DATA

The analysis presented in this paper is supported by several sources of data. It draws together forecasts of the Bureau of the Census, experts in traffic safety. and key representatives of the automotive and supplier industries. In addition, it draws on some of the organizational methodology of influence diagrams and scenario development. Because of restrictions on the development of this paper, it was not possible to fully implement any of these methods or others that are available. Rather, the paper represents an introduction to the challenges ahead coupled with suggestions on how to address them.

TRANSPORTATION AS AN INTEGRAL PART OF THE SOCIOECONOMIC SYSTEM

In any discussion of a transportation system -- intelligent or otherwise -- it is useful to begin with a placement of it in the larger social system. The transportation system is not a stand-alone system and cannot be studied in isolation. Economists refer to the demand for transportation as a derived demand. By this is meant that there is practically no demand for transportation in and of itself. With the exceptions of those of us who like to drive cars, fly planes, or ride in buses or trains (thrill seekers, those enchanted by movement, machines, or the lure of the sky or road), we use transportation for the purpose of meeting some other need -- that of getting to some place of business, social, educational, shopping or other activity.

The social/economic activity system -- employment. housing, schooling, health care, shopping, socializing, etc. -- has a vibrant life with its own changes and interactions. The transportation system is planned and built by a combination of public and private enterprise and, to some extent, changes through the impetus of those responsible for planning and implementing such systems. In addition, the transportation system is affected by changes in the social/economic system and, in turn, the availability of transportation directly affects the function of the social/economic system. For example, a rural community begins; roads are built to the area; industry relocates because of transportation availability; housing is built to house workers and their families; schools and shopping centers are built to serve those families; more roads are built to accommodate the growing commercial and personal travel; and so on. Figure | illustrates the relationship of the transportation system and the larger social/economic/politicalsystem. It lists just a few of the social, economic, political, and other factors that interact with the transportation system such as neighborhoods, privacy, taxation, employment, regulation, age, gender, and immigration. Note in the figure that the two systems change as a result of activity within themselves (including the actions of planners and engineers responsible for transportation systems) and that each changes as a result of the activity in the other.

Waller (1994), Sobey (1990) and others have suggested many of the societal and economic factors that might be or relevance in the planning of a transportation system. Table 1 lists some sixty-one of them. This list is not meant to be exhaustive, but rather a glimpse into some of the complexity and challenges that exist in implementing transportation systems.

As growth of social/economic and transportation systems continues, there are major benefits that are experienced including economic prosperity, better access for some members of society to life's necessities, etc. At the same time, there may be many negative consequences of growth including air, noise, and water pollution, the deterioration of inner cities, the loss of open land. congestion in cities and in the residential and commercial areas surrounding them. There are many other social indicators such as increasing crime rate, lack of access to health care for people living in the inner cities, increase in the teen birth rate, increase in drug use, inability of inner city residents to get to employment in suburban areas, destruction of urban neighborhoods, a tearing of the social fabric, benefits for the haves and costs for the have-nots, health effects from air pollution accompanied by a decrease in the quality of life for those who live in smogenclosed areas, an inability to swim in or drink polluted waters, etc. It is not clear that there is a direct relationship between transportation services and these conditions, but they cannot simply be written off when planning a new type of transportation system. Consideration of them can be made by use of any of several analytical methods, some of which are listed below.

SOCIETAL AND ECONOMIC FACTORS AFFECTING AND AFFECTED BY TRANSPORTATION

There are many societal and economic factors that affect transportation systems and/or are affected by them. Several efforts have been made to identify these, although not specifically for the purposes of intelligent transportation systems planning. The Bureau of the Census provides demographic forecasts for several years into the future. A set of symposia on critical issues in traffic safety in the year 2010 provides another source of "forecasts." A third source of data is a Delphi study of the future of factors related to the automotive industry. Data from each of these are presented below.

Census Forecasts

It is useful for planning purposes to look at the current population level and composition and Census estimates for the future. Table 2 lists 1995 population estimates for the United States for men and women, disaggregated into those greater than or equal to 16 years of age and those greater than or equal to 65 years of age. This breakdown gives us the numbers of people who are eligible to have drivers' licenses and those who are in the pool to be elderly drivers. Total U.S. population is also included, as is the ratio of women to men and the percent of population (disaggregated by gender) that is elderly (greater than or equal to 65).

Tables 3 and 4 provide the same information for the years 2005 and 2050. The data for 2005 are a base for a relatively near-term planning forecast, while the 2050 data give us a view of time when most of us will be either very old or no longer alive. Even though we may not be able to reap the benefits of our planning ourselves, perhaps our great-grandchildren will. Of note are the increasing numbers of the population, the elderly (both men and women), with the population of older men increasing at a higher rate than that of older women. Note that by 2005, almost 13% of the population will be elderly, with about 1.5 million more elderly women and about 1.8 million more elderly men than in 1995. By 2050, 20% of the population will be over 64 years of age. This has direct implications for both time horizons for access to societal activities, ergonomic design of vehicles, safety, intermodalism, etc.

Critical Transportation Issues

When traffic safety experts convened in 1992 under the sponsorship of American Iron and Steel Institute and The University of Michigan Transportation Research Institute to identify critical issues in traffic safety in 2010, they hypothesized what the future would hold in terms of driver behavior, vehicle occupants, vehicles, and the highway environment. (Richardson 1993) They suggested (but did not agree on) the following scenario:

"Drivers will:

- continue to drive drunk and drugged
- continue to want personal transportation, greater speed, and perhaps more vehicles per person
- include more older, female, immigrant, and minority people
- demand different types of vehicles from now, e.g., vans vs. muscle cars
- expect that the vehicle and the highway infrastructure should protect them in the event of a crash demand more socially responsible vehicles
- not change their attitudes about vehicles
- not buy safety for safety's sake
- change their driving patterns because of working at home, living in rural work communities, use of alternative vehicles such as motorcycles and bicycles, and changes in the types of vehicles available

Vehicle occupants will:

- change in terms of their size, physical condition, demographics, out-of-position locations in the vehicle, and ergonomic requirements
- · have more disabling injuries in relation to fatalities
- have high medical costs due to injuries.

Vehicles will:

- have greater differences and incompatibilities among them technologically because of the aging of the fleet
- contain new technology such as intelligent vehicle highway systems (IVHS) or alternative fuels with uncertain safety impacts.
- be subject to different regulations such as stricter Corporate Average Fuel Economy (CAFE) standards
- be designed for ease of assembly, disassembly, recyclability
- contain light-weight materials such as composites and aluminum
- have airbags front, rear, and side; obstacle detection systems; ABS; speed control; enhanced vision systems
- have higher prices due to the built-in expense of vehicle manufacturer employee health care coverage.

The highway environment will:

- · contain more vehicles of various sizes and technologies
- · not increase significantly in terms of new miles of highway built
- · have more travel and congestion
- · deteriorate due to poor maintenance of the infrastructure
- · not safely accommodate drunk and drugged drivers
- · have more hazardous materials carried on them.

Given these future characteristics, tradeoffs will exist between:

- · safety and other vehicle design goals
- · safety and other public goals
- · safety and mobility
- infrastructure maintenance and other goals
- police resources for enforcement of speed, alcohol use, and other safety factors vs. other crime needs
- · impairment detection and willingness to pay.

Further, without concerted thinking, planning, and implementation, no one will:

- provide coordination among the plethora of data bases available, e.g., police data bases and medical facility data bases
- reduce or eliminate actions on the part of politicians, the media, and industry (particularly alcohol) that are potentially counterproductive to efforts to promote safety
- provide effective integration of transportation into the larger society, e.g., locations of places of employment, shopping, alcohol-licensed establishments
- · modify product and tort liability legislation so as to enable the development of new products and practices to facilitate the efficiency of the transportation system and to enhance safety
- · coordinate and facilitate the intermodal transfer of both people and goods
- · coordinate the efforts of local, state, and federal governments and other organizations in improving safety
- control the growth of medical costs through preventive measures, including primary, secondary, and tertiary prevention."

Although traffic safety was the area of focus for this scenario, the symposia participants are also experts in the broader field of transportation, and their insights can be applied directly to the situation surrounding the planning and implementation of intelligent transportation systems. For example, drivers will have similar attitudes

pertaining to their transportation, whether planners are thinking of safety or IVHS. Therefore, it can be anticipated that drivers will expect that they will be taken care of by forgiving vehicles and environments; have different driving patterns; and not voluntarily curtail their drinking and driving. These drivers will be carrying passengers who will be different from today's passengers in terms of size, age, physical condition, demographics, and ergonomic requirements. Vehicle occupants will be older, more likely female, and larger and smaller than they are today. Vehicles are expected by this group to offer new technology and therefore be in potential conflict on the roadway with older, not so well equipped vehicles; have more safety equipment: and cost more than they do today. At the same time, it is expected that the roadway infrastructure will deteriorate. All this will occur in a time of a lack of cooperation across organizational entities. The waming is given by this group of experts that it is now past time to consider how to address many of the societal issues that come to bear on the transportation system and to coordinate transportation planning and implementation activities across organizational boundaries. In fact, of the over fifty issues identified by this group of experts as being important in traffic safety in 2010, the vast majority of them had to do with the people and institutional aspects of the transportation system rather than the technological ones.

Some of these same societal and economic issues are raised by Pisarski (1994). He indicates that there are societal forces of stability such as population, labor force age, drivers' licenses, vehicles, women workers, and vehicle miles of travel (VMT) "ceilings." Also, there are forces of change including women, immigrants, the young and old, low income, and the inner city. Although the traffic safety experts did not address forces of stability, these forces of change are totally consistent with those raised by them.

Delphi Forecasts of the Automotive Industry

A Delphi survey conducted by the Office for the Study of Automotive Transportation at The University of Michigan (Cole et al. 1994), contained the following opinions on circumstances in the year 2003. There were over 200 Delphi panel members who participated in one of three panels: Marketing, Materials, or Technology. These people are in senior management in the automobile manufacturing industry or the automotive supplier companies, or are practicing scientists or engineers. The views expressed are their current opinions of what the future will be like in about ten years. The responses reported here are based on the median scores of the panel members for the questions asked.

Political and Economic Factors Affecting Business Strategy

The forecasts of several of the political and economic factors affecting automotive business strategy (and therefore also other economic conditions) showed little change the next ten years. Among these are the personal taxation rate, business taxation rate, federal budget deficit, personal savings rate, trade value of the U.S. dollar, the trade deficit, and the unemployment rate. On the other hand, increases were expected in manufacturing competitiveness, annual GNP change, and energy prices.

Economic, Social, and Consumption Factors

Economic, social, and consumption factors that influence the level of new vehicle demand that were expected to increase slightly over the next ten years include the age of the operating fleet, real transaction price of new autos, used car prices, vehicle insurance premiums, personal loan interest rates, use of mass transportation, and real disposable personal income. None of the economic, social, nor consumption factors were expected to decrease.

Fuel Prices

Compared to a baseline of \$1.10 in 1992 for a gallon on unleaded regular gasoline, panelists estimated that the equivalent real retail price of gasoline per gallon in the U.S. in 2003 will be \$1.70.

Federal Regulatory and Legislative Activity

It is anticipated that the following U.S. Federal regulatory and legislative standards will be somewhat more restrictive in 2003 than they are in 1994: fuel economy standards, occupant restraint/interior safety, product liability, vehicle integrity/crashworthiness, and vehicle emission standards.

Manufacturers Suggested Retail Price

Compared with a model year 1993 Manufacturers' Suggested Retail Price of \$16,186 for an intermediate/family car, panelists expected the equivalent car prices in 2003 to increase as follows: Big 3 at \$19,000, Japanese nameplate at \$19,600, and European and others at \$22,000.

Vehicle Age and Ownership Periods

Delphi Study panelists estimated that the average age of passenger cars in the United States will increase from 7.9 years in 1992 to 8.5 years in 2003, and that the length of ownership by new car buyers will grow from 5.5 to 6.0 years over the same time period.

Vehicle Sales Smart Vehicle Features

Panelists estimated the following total U.S. passenger new-car market, domestic and import, penetration rate (in percent) for the following "smart" vehicle systems for 2003:

Near-object detection (back-up warning)	3
Adaptive cruise control	7
Collision warning (front, rear, and side radar)	5
Night vision enhancement	5
Radio call for help locator	10
Automatic toll collection	5
Navigation	5
In-vehicle message system	10

CAFE Standards

The Delphi panel members expect that the CAFE standards that can be reached by the different manufacturer groups by 2003 are:

Traditional domestic	32 mpg
Japanese - foreign and domestic	35 mpg
European - foreign and domestic	30 mpg

The expectations provided by the Delphi panelists give us some insight into what the future of factors affecting intelligent transportation system technology might be. If we aggregate the expectations pertaining to these factors, we can suggest the following scenario of the future. This scenario would have increasing vehicle and fuel prices and average age of vehicles on the road causing a dampening effect on the increase in demand for new vehicles, somewhat offset by a growing population needing cars and a modest increase in real disposable income. One indicator of this trend will be the increasing average age of new-car ownership. The new cars sold will be more energy efficient. safe, and environmentally friendly, although only a very small portion of them would be equipped with "intelligent" technology, perhaps because of the cost of the new technology. Because of the higher cost of cars and fuel, those people needing transportation may buy less expansive cars or switch to other, less expensive, modes of transportation. However, there would not be a decrease in vehicle miles of travel if the effects of higher fuel and vehicle prices are counter-balanced by the greater fuel efficiency of new vehicles and an increase in population.

Travel Trends

In 1992, 98T of the vehicle miles of travel (VMT) in the United States were on the highway. (U.S. Department of Transportation 1993) Between 1983 and 1990, VMT in the United States grew by 40%. Causes for this increase were distributed among the following factors by the percent noted: population increase (13%), person trips per capita (18%), mode shift (16.6%), vehicle occupancy (16.6%), and trip length (35.9%). Much of the increase in trip length was due to longer work trips which increased by 29% over the seven-year period. (U.S.

Department of Transportation 1992) To the extent that work trips continue to grow in the future as they have in the recent past, there will be definite implications for increased congestion in the non-traditional work-trip commute areas.

IMPLICATIONS OF FACTORS FOR INTELLIGENT TRANSPORTATION SYSTEMS

Table 5 contains a listing of the IVHS User Services. (IVHS AMERICA 1994). It includes twenty-eight technologies that may be offered over the next several years. For the purposes of presentation in this paper, they are aggregated into their service groupings and presented in figures 2 and 3, respectively, along with some of the societal and economic factors that may affect them or be affected by them (in a positive, negative, null or uncertain way). These figures represent a preliminary and speculative attempt, without specific analysis, to synthesize the forecasts of several groups and individuals into influence charts. These charts are not meant to represent the ultimate "truth" on the relationship between societal factors and transportation systems, but rather are offered as discussion starters. Although the charts do not address the locational issues, it is important to recognize that every impact of an intelligent transportation system is felt at the local level. At the same time, it is necessary to consider regional, national, and international impacts that may occur. Note that the first row of Figure 2 shows the expected penetration rates of various intelligent transportation technologies into the new-car fleet. These are based on the expected penetration of one of more of the technologies in the user service group as estimated by the Delphi study panel members. The charts show a wide range of types of relationships, and future research aimed at establishing and quantifying these relationships is necessary.

ANALYTICAL METHODS TO ADDRESS SOCIOECONOMIC ISSUES

There are many analytical methods available to address the societal issues attendant to the deployment of an intelligent transportation technology. Albers and others (1994) presented several of these at the 1994 SAE International Congress and Exposition. He and others on a subcommittee of the Societal Implications Task Force of IVHS AMERICA are in the process of compiling an inventory of such methods. It is expected that the inventory will be completed by the end of 1994. Among these methods are decision analysis, conflict resolutions techniques, focus groups, Delphi studies, futuring, scenario development, influence diagrams, scanning and monitoring the environment, econometric analysis, epidemiological techniques, and expert systems. These methods have been used widely in many sectors of the economy, but not extensively in the transportation systems analysis arena. Other methods, such as the "direct legitimacy approach" rely on direct system user input (Hauer 1994) All these methods represent fertile ground for exploratory research for application of methods and the opportunity to incorporate into the planning process the societal issues with a rigor that exceeds simple acknowledgement and discussion.

FUTURE RESEARCH NEEDS

In order to begin to address the societal and economic factors that interact with the transportation system, there is an abundance of work that must be done. First, the issues that are not considered to be technical issues must be identified and categorized in some logical way. Second, some attempt must be made to quantify the impact of those factors on the transportation system and the effects of changes in the transportation system upon them as well. To do this properly, an identification of the available analytical techniques needs to be made followed by demonstrations of their applicability to the societal/economic arena in transportation systems analysis and planning. Some will prove to be useful, while others may not. There is every reason to pursue this line of research, and a few reasons not to begin now.

SUMMARY AND CONCLUSIONS

This paper represents an identification of many of the societal and economic issues attendant to transportation systems, a summary of several efforts to forecast the future pertaining to transportation systems and the environment surrounding them, an effort to link them together in a relational way, and a call for attention to be focused on addressing this issue as analytically as possible as early as possible in the planning for the implementation of intelligent transportation technology.

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Table 1 A Potpourri of Societal and Economic Factors

Access of disadvantaged groups such as the poor, the young, the aged, and the physically disadvantaged.

Access to employment Isolation of Population in rural or urban areas

Access to education
Access to health care
Access to housing
Access to shopping
Access to shopping
Affordability
Air pollution
Availability of food and energy

Legal issues
Jurisdictional issues
Market forces
Minorities
Modal choice
Availability of food and energy

Neighborhood wightile

Availability of food and energy

Crime

Competing social goals

Noise pollution

Competing social goals
Congestion

Noise pollution
Non-users of transportation system

Consensus process

Quality of life

Cross-organizational cooperation Participation in society

Cyclists Privacy
Day care Product and tort liability

Day care

Defense industry refocus

Public/private interactions

Demographics Recreation
Economic growth Regulation
Economic stability Retail sales
Education Safety

Employment availability

English as a second language

Security

Societal attitudes

Equity Telecommuting Funding - privately Teleconferencing

Funding - publicly

Transit availability and use

Gender Truckers
Health care availability Unemployment
Immigration Vehicleownership
Income Water pollution

Income Water pollution
Intermodal transfers Who pays/who benefits

Table 2. CENSUS FORECASTS - 1995 US Population (Thousands)

AGE	TOTAL POPULATION	MALES	FEMALES	FEMALE/ MALE
>I6	201,543	96,964	104,579	1 .08
<u>56</u> 5	33,649	13,699	19,950	1.46

Total Population263,434Elderly Males/Tot. Pop.0.052Elderly Females/Tot. Pop.0.076Elderly People/Tot. Pop.0.128

Table 3. CENSUS FORECASTS - 2005 US Population (Thousands)

AGE	TOTAL POPULATION	MALES	FEMALES	FEMALE/ MALE
>16	223,469	107,880	115,589	1.07
>65	36,970	15,534	2 1,436	1.38

Total Population288,286Elderly Males/Tot. Pop.0.054Elderly Females/Tot. Pop.0.074Elderly People/Tot. Pop.0.128

Table 4. CENSUS FORECASTS - 2050 US Population (Thousands)

AGE	TOTAL POPULATION	MALES	FEMALES	FEMALE/ MALE
≥16	3 10,626	150,350	160,275	1.07
≥65	80,109	36,092	44,016	1.22

Total Population392,03 lElderly Males/Tot. Pop.0.092Elderly Females/Tot. Pop.0.112Elderly People/Tot. Pop.0.204

Source: U.S. Bureau of the Census (1992)

Table 5 **IVHS User Services**

Travel and Traffic Management

Pre-Trip Information

En-Route Driver Information **Traveler Services Information**

Route Guidance

Ride Matching and Reservation

Incident Management

Travel Demand Management

Traffic Control

Public Transportation Management

En-Route Transit Information Public Transportation Management

Personalized Public Transit **Public Travel Security**

Emergency Management

Emergency Vehicle Management

Emergency Notification and Personal Safety

Commercial Vehicle Operations

Commercial Vehicle Electronic Clearance **Automated Roadside Safety Inspection** Commercial Vehicle Administrative Processes **On-Board Safety Monitoring**

Commercial Fleet Management

Hazardous Material Incident Notification

Electronic Payment

Electronic Payment Services

Advanced Vehicle Safety Systems

Longitudinal Collision Avoidance Lateral Collision Avoidance Intersection Collision Avoidance

Vision Enhancement for Crash Avoidance

Safety Readiness

Pre-Crash Restraint Deployment **Automated Vehicle Operation**

Source: IVHS AMERICA (1994)

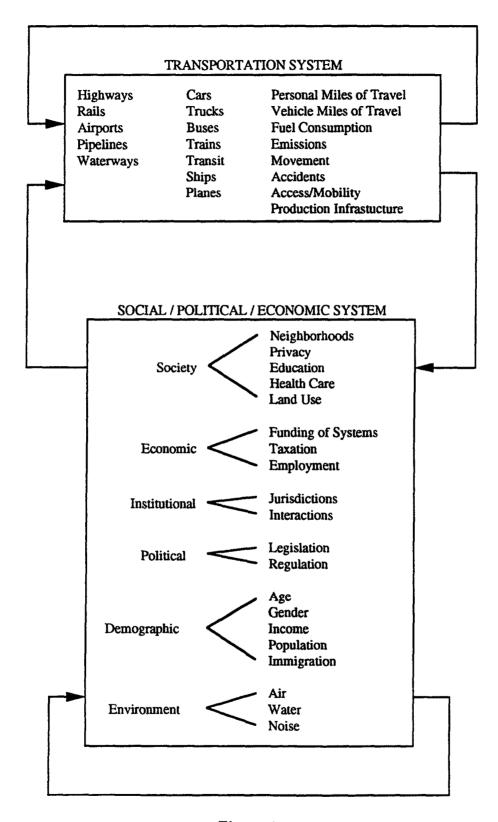


Figure 1
Interactions of the Transportation System with the Social/Political/Economic System

+ Positive Impact- Negative Impacto NoImpact? Uncertain	Advanced Vehicle Safety Systems	Emergency Management	Commercial Vehicle Operation	Electronic Payment	Public Transportation Management	Travel & Traffic Management
Liklihood of Penetration (2003) (%)	3-10	10		5		5
Population Growth	0	0	+	+	+	+
More Elderly	0	0	0	?	+	+
Highway Constraint	0	0	+	+	+	+
Regulation	+	+	+	?	+	+
Drunk Driving	0	0	0	0	+	+
Ergonomic Changes	0	0	0	0	?	?
CAFE	0	0	+	+	+	+
Clean Air Regulations	0	0	+	+	+	+
VMT Increase	0	+	+	+	+	+
Poor Highway Maintenance	О	+	?	?	+	?
Little Coordination Across Institutions	-	-	?	?	-	-
Litigation	-	-	-	•	?	-
Energy Price Rise	0	0	?	+	+	+
GNPGrowth	+	+	+	+	?	+
Increasing Age of Fleet	o		?	?	?	?
Increase in Car Price	-	-	?	+	+	?

Figure 2 Socioeconomic Factors Affecting Intelligent Transportation Systems

Advanced Vehicle Safety Systems	Emergency Management	Commercial Vehicle Operation	Electronic Payment	Public Transportation Management	Travel & Traffic Management	 + Positive Impact Negative Impact O No Impact ? Uncertain
-	-	0	0	+	+	Access by Disadvantaged
-	-	0	0	?	-	Affordability
0	0	+	+	+	+	Air Pollution
0	0	?	+	?	?	Crime
?	0	+	+	+	?	Congestion
+	?	?	?	?	0	Cyclists
0	0	0	0	+	0	Health Care
+	?	0	0	+	ı	English as Second Language
0	0	0	ı	+	0	Intetmodal Access
0	0	0	•	+	+	Isolation
-	-	?	•	?	•	Legal Issues
0	0	0	-	+	0	Neighborhood Viability
0	o	+	+	•	0	Noise Pollution
-	•	?	-	•	?	Non-Users of System
-	-	-		?	?	Privacy
0	O	0	0	?	+	Recreation
+	+	+	0	?	0	Safety

Figure 3
Socioeconomic Factors Affected By Intelligent Transportation Systems

MR. MUNNICH: I would like to thank all of the panelists for their presentations.

DR. HORAN: I certainly commend you for all the listening you have done. We are approaching the end of the input and will look forward to leaving this part of the program and initiating some dialogue. We will adjust the schedule so that this panel and the breakout groups have enough time.

Let us move now to the next panel which will be chaired by Steve Crosby who, as many of you know is Chairman of the Smart Route Systems in Boston which is a unique public-private arrangement. Steve's organization also provides associated services and products in New England, and he is on the advisory boards of many experimental public-private arrangements around the country.

IVHS APPLICATIONS TO SUPPORT ENVIRONMENTAL GOALS

Moderator: Steve Crosby Chairman, SmartRoute Systems

INTRODUCTION

MR. CROSBY: Thank you, Tom. The program today has followed a logical flow, and it culminates as Tom said in this afternoon's final panel, which focuses on trying to build a common data base of ideas, perspective and information which will serve as the building block for the discussions that follow in the breakout sessions.

We started this morning with vision and then went back to vision during the luncheon speakers' presentations. We then had a status report from IVHS AMERICA and the U.S. Department of Transportation on where ITS is and the policy opportunities and constraints. This panel focuses on applications in IVHS, but I think of it more as a series of analytic tools and conceptual structures that we can use to help assess the costs and benefits of IVHS applications and the role of IVHS with respect to the environment. This industry, it seems to me not unlike a number of others, is prone to being discussed with assumptions and presumptions about facts and data which are largely unfounded with in part because there has not been much opportunity to obtain the substantiation and in part because people are just anxious to talk about it and not to focus on the actual analysis to give us the real data that will enable us to talk about things intelligently.

I think of two examples in particular. One is the mostly tacit assessment or conviction that we have heard a lot about today that use and application of IVHS technologies will increase vehicle miles traveled, i.e., pulling out VMT from some kind of a latent demand. That may or may not be the case, but there is not much in the way of data to back it up.

Similarly and an example that I am very familiar with since my Smart Route Systems is in the ATIS business, there is a assumption that consumers (travelers) have some interest in advanced traveler information and in IVHS technologies and that after we go through all this angst of bringing them to market, and that consumers will actually use them. And again, there is very little in the way of data to back that up.

It is not uncommon in public policy debates that there is more heat than light. However, it is not a very constructive way to have public policy debates. As you hear the speakers today there are several interesting analytic tools to help us use or come up with real data to make the kind of judgments and public policy decisions that are being required of groups like this and of the whole IVHS movement.

Now, in particular, Sal Bellomo will present a strategy for assessing the environmental costs and benefits of various multimodal mixes. He suggests how a review of those costs and benefits ought to be much more thoroughly integrated into the IVHS infrastructure and fabric.

Sergio Ostria offers what I have found, even as a neophyte in economics, a fascinating economic analysis that actually attempts to set out a structure for evaluating the impact of IVHS on travel demand.

Carol Zimmerman will speak to the issue of what we know and, as much, what we don't know about actual user acceptance of IVHS. Lisa Saunders will help us establish a framework for considering the equities of IVHS deployment in particular with the focus on the impact of IVHS on disadvantaged communities.

All four of these are analytic perspectives and conceptual perspectives and data bases that we need real knowledge about if we are to be constructive in assessing the kind of problems that we are considering now.

HOW RESPONSIVE MULTIMODAL TRANSPORTATION MANAGEMENT LINKED TO IVHS CAN IMPROVE ENVIRONMENTAL QUALITY

Dr. Salvatore J. Bellomo, P.E. Mr. Andrew Sullivan Bellomo, McGee, Inc. (BMI) Vienna, Virginia

INTRODUCTION

Objectives

This paper has the following four objectives:

- To review Multimodal Transportation Management Strategies Linked to IVHS
- To review the potential of various strategies and technologies to improve environmental quality
- To discuss a process by which IVHS can be involved in environmental evaluations
- To outline concerns that should be addressed to improve the Multimodal IVHS Environmental Quality Process

Background

Responsive Multimodal Transportation Management Strategies include those actions which involve more than one mode of transportation, provide real or semi-real time information to users of IVHS technology, and achieve the following goals and objectives established by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA):

- 1) Improve the market share and operations of high occupancy vehicles (HOV), ridesharing and mass transit;
- Provide for more efficient use of existing transportation facilities and resources;
- Provide for more efficient use of energy sources;
- Enhance the efficiency of urban goods movement;
- 5) Improve the usefulness of existing TSM strategies;
- 6) Improve air quality;
- 7) Improve transportation safety;
- Improve the economic efficiency of transit and paratransit operations;
- Improve the mobility of the elderly, handicapped. and the transportation disadvantaged; and
- 10) Improve mobility in rural areas.

This paper presents findings related to conceptual evaluations of scenarios from a two year FHWA/FTA project conducted by a team led by Bellomo-McGee, Inc. (BMI). The objectives of the research study were to:

- 1) Identify candidate real or semi-real time multimodal transportation management scenarios which use new and emerging IVHS technologies;
- Determine their usefulness and feasibility;
- Develop additional innovative concepts;

- 4) Evaluate the potential utility and cost of each scenario; and
- Provide recommendations for additional research, development, and operational tests.

A framework for evaluating the potential benefits and costs of multimodal functional scenarios was successfully applied to a conceptual evaluation of some 27 scenarios involving mass transit, paratransit/ridesharing, general highway multimodal, airports, and commercial ports/intermodal facilities. This conceptual evaluation addressed environmental effects and can also be transferrable to the IVHS America mode-specific 27 user groups identified as part of the United States Department of Transportation (USDOT)/IVHS Strategic Program Plan Draft.'

The conceptual evaluation of environmental effects focused on the physical and socioeconomic environment and was based on studies and research to date. Physical environmental effects covered potential impacts on traffic (improved HOV, rideshare, and mass transit, better use of existing facilities) traffic safety. air quality (reduced emissions) and energy (efficiency improvements). Socioeconomic areas effects included improved mobility for the elderly, handicapped and transportation disadvantaged, improved rural area mobility, and potential human factors effects. It should be noted, however, that the precise environmental effects of many of these technological advances will not be known until proper evaluations are made during operational tests, data is gathered, and improvements in models are completed.

Before proceeding with the paper, it is important to overview the assumptions and scenarios used in the research.

Assumptions:

The scenarios presented in this paper were developed for a mature IVHS environment that is assumed will exist at some time in the future. The following assumptions have been made about the expected level of IVHS maturity in the urbanized areas and in major rural highway corridors under implementation consideration for this study:

- Traffic signal control, freeway management, and transit fleet management systems have been deployed throughout most of the area.
- The systems are physically/electronically linked.
- Each location has a Transportation Management Center (TMC), similar to Exhibit where information is received, fused, and disseminated to travelers.
- Commercial vehicles are linked to fleet management centers which provide them with traffic and route information.
- There is a large market penetration of in-vehicle navigation devices whereby the above information is provided to passenger car, transit vehicle, and commercial vehicle drivers and recommended routing is provided based on real-time information.
- Reduced scale in-vehicle systems which provide continuous traffic information on selected corridors are also available. They are less sophisticated and less costly than the fully functional ATIS devices described above.
- Traffic information centers and systems, similar to those described above, exist in major rural highway corridors and areas. However, these systems are not deployed throughout the entirety of the rural networks.

These functional requirements were taken as given during the development and evaluation of the candidate scenarios. Exhibit 2 presents selected criteria used for the evaluation of the multimodal transportation management strategies linked to IVHS. This study was not concerned with the practicality of these requirements or whether or

not they are attainable, rather the focus was on how the candidate scenarios would perform given this assumed operating environment.

Scenarios:

The 27 candidate multimodal scenarios are discussed here. Although all scenarios have multimodal applications, they are presented according to their major modal applications:

- Mass Transit (10)
- · Paratransit/Ridesharing (5)
- · General Highway/Multimodal (7)
- · Airports (1)
- · Commercial Ports/Intermodal Facilities (4)

Mass Transit Scenarios have been designed to increase transit usage, enhance the efficiency of transit operations, ease transit use, and improve the overall quality of mass transit services. The scenarios include applications to route deviation service, transit management information, smartcards, and automatic vehicle location systems.

Paratransit and Ridesharing Scenarios were designed to increase the use of HOV and ridesharing, enhance the operations of paratransit services, and generally improve personal mobility in both urban and rural environments. The scenarios include real-time ridesharing, improved paratransit dispatching, rural ATIS systems, and using courier vehicles to move people on HOV facilities.

General Highway/Multimodal Scenarios were designed to improve travel on the transportation system and encourage the awareness and use of alternate modes of travel. The scenarios included providing travel information in homes and workplaces, using IVHS to reduce travel demand during air quality alerts, using ATIS to monitor parking availability, and developing a hand-held portable ATIS unit.

The Airport Scenario was designed to improve travel and traffic flow at airports.

Ports/Intermodal Facilities Scenarios were designed to improve the operation and efficiency of intermodal port and rail facilities. The scenarios provide for improved truck access to ports and rail facilities, improved vehicle processing at ports, and coordination of river and drawbridge traffic.

Organization

The paper is organized into five sections. Section 2 presents the multimodal transportation management scenarios and environmental concerns identified during the conduct of workshops. Section 3 highlights at a conceptual level broad, potential environmental effects. Section 4 discusses how multimodal transportation management can be related to the environmental processes. Section 5 presents concerns that need to be addressed and Section 6 presents conclusions.

MULTIMODAL TRANSPORTATION MANAGEMENT SCENARIOS

The study developed 27 conceptual IVHS scenarios covering a wide range of modes, user services, and areas of applicability. Exhibit 3 presents a sample scenario, "Air Quality Alert." Its purpose is to assist transportation managers in air quality non-attainment areas to manage travel during air quality alerts. Exhibit 4 presents a summary evaluation of this scenario based on each of the evaluation criteria identified in Exhibit 2 (more detailed evaluations were also performed and included as an appendix to the Final Report).

Modal and Area Applicability

Exhibit 5 presents a correlation of the 27 scenarios to their various **modes.** While all of the scenarios are multimodal in scope, they are grouped according to their primary mode of application. In developing these scenarios, an attempt was made to consider all modes, and not just the traditional highway modes.

Linkage to IVHS

Exhibit 6 correlates each of the scenarios with the relevant IVHS technology areas (ATMS, ATIS, CVO, APTS, and AVCS) and areas of applicability. It can be seen that many of the scenarios have correlations to several IVHS technology areas.

It should be noted that although each scenario is listed individually, the scenarios can be combined in "packages" which might yield greater benefits than what could be obtained from the scenarios individually. For instance, scenario 18 "Air Pollution Alert," scenario 11 "Real Time Ridesharing," and scenario 4 "Transit Park & Ride Information" could be combined for use during air quality alerts or special events to encourage travelers to use carpools or transit. Together, they would likely encourage greater use of alternate modes than any one scenario would on its own.

Not all scenarios, however, could be combined with positive results. While some combinations would enhance the overall benefits, others may prove counterproductive. Exhibit 7 presents the interrelationship between multimodal transportation action groups. It can be seen that some action groups assist one another, some are independent of one another, and others are counterproductive. Before operational testing or implementation, careful consideration will need to be given to how an IVHS scenario will interact with other transportation management measures already in place in an area.

Environmental Concerns

As part of the study, a series of eight workshops were held at sites across the country. The one-day workshops were attended by transportation professionals from Federal, State, and local highway and transit agencies, representatives from airport and port authorities, and transportation planners from State planning agencies and MPOs. At the workshops, various participants discussed their concerns for IVHS and the environment. Some of the key points are summarized in Exhibit 8.

Relationship to Operational Tests

A final task of the study was to correlate the 27 scenarios with on-going or planned IVHS operational tests. This helped to identify potential test sites where each of the scenarios could be tied into ongoing tests. The correlation identified all ongoing and planned IVHS operational tests in the U.S. and determined whether they could provide a useful basis for testing any of the candidate scenarios. Exhibit 9 presents a sample correlation of a candidate scenario ("Transit Route Deviation") with ongoing operational tests. These correlations were useful not only for identifying sites where the candidate scenarios could be tested, but also for identifying areas where there is currently not enough IVHS research being done. The areas where there was a lack of current activity included air quality, environmental concerns, and inter-modal ports and terminal facility operations. None of the IVHS operational tests currently being conducted in the U.S. has as one of its primary goals the reduction of air emissions or the improvement of environmental quality.

This is important for two reasons. First, it shows that not enough focus in IVHS research has been put on the potential for IVHS to improve the environment. Environmental concerns are often being addressed only as secondary impacts of IVHS research, not as primary goals. Secondly, the lack of operational test activities means a corresponding lack of available operational test data on which future evaluations of IVHS environmental impacts could be based. There is currently very little data on the potential environmental effects of IVHS.

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POTENTIAL ENVIRONMENTAL EFFECTS OF SCENARIOS

Range of Environmental Effects

Intelligent Vehicle Highway Systems have the potential to create positive environmental effects in a number of areas, including reductions in congestion and vehicle emissions, reduced VMT, improved safety, and improved economic efficiency. Exhibit 10 presents a list of environmental elements and potential IVHS effects. It should be noted that the magnitude of these potential impacts remains to be determined through modeling and operational testing.

Analytic Uncertainties

There are inherent uncertainties in trying to assess the potential impacts of IVHS scenarios. Current models are not necessarily accurate and may not consider the full range of IVHS impacts. This problem was discussed by Brand in a paper describing criteria and methods for evaluating IVHS plans and operational tests. In the past, techniques for evaluating IVHS scenarios and operational tests have tended to underestimate the mobility and personal benefits of new technology and have not taken into account the time frame for impacts or the differences between supply and demand impacts. With IVHS, evaluations must be based not just on the use of infrastructure, but on the use of information as well.' Traditional evaluation methods may therefore not provide accurate estimates of potential benefits and costs.

There are similar uncertainties with the existing models used to project impacts of IVHS scenarios, particularly as they relate to air quality. Current emission models have high levels of uncertainty and may not yield accurate forecasts. Combined with the uncertainties associated with the impacts of IVHS on VMT, travel patterns, and transit/HOV use, the magnitude of potential environmental impacts are unclear.

RELATING MULTIMODAL IVHS TO ENVIRONMENTAL PROCESSES

The previous sections have highlighted the multimodal IVHS scenarios and potential environmental effects as well as uncertainties. For IVHS to be fully integrated and implemented, it will need to be incorporated into ISTEA, CAAA, management systems, planning activities, and the NEPA process.

Congestion Management and Air Quality

Multimodal transportation management strategies linked to IVHS have potential impacts on ISTEA's management system requirements, particularly the Congestion Management System (CMS), which is one of the six major management systems. Other management systems that could benefit from IVHS advanced technologies could include: Intermodal, Public Transportation, Highway Safety, Highway Pavement and Bridge Management Systems.

Exhibit 11 illustrates a general CMS process for addressing recurring congestion, non-recurring congestion, and air quality. As indicated, multimodal and mode specific actions incorporating IVHS technologies should be considered and evaluated with respect to their effectiveness along with other actions. It will be important to know the effects for existing, short term, and long term conditions. The challenge of examining IVHS will be to evaluate the use of information (not just infrastructure) on a real time basis. Presently, our analytic procedures and data are not providing practitioners what is needed for definitive evaluation. If IVHS is to be implemented, it will need to address state of the art improvement and present the relevant costs and environmental effects to the decision makers. Principles related to this new evaluation process where highlighted by Brand at TRB.5

State and Local IVHS Strategic Plans

Incorporation of environmental quality concerns should be an integral part of IVHS Strategic Plans under development and refinement by State and Local governments. Most plans today highlight current and planned demonstrations of transportation -- IVHS applications with a focus on the technical feasibility of the technology. Often times, many of the demonstrations give a cursory view of the evaluation activities rather than making it a

forma] activity up front. This environmental evaluation will need to be done using best available data and models. As noted at the National IVHS and Air Quality Workshop³ there needs to be a stepped up effort in micro and macro scale models and data in order to achieve this improvement with respect to the IVHS Strategic Planning process,

State and Local LRTP's and SIP's

To increase the implementation of multimodal transportation management, IVHS will require incorporation of these actions into State and Local Long Range Transportation Plan (LRTP's) and State Implementation Plan (SIP's). A key problem here is evaluation methodology and clear communications on the costs and environmental benefits, particular details on how the transportation/IVHS action contributes to the reduction of emissions and achievement of air quality standards.

In conducting the multimodal IVHS workshop, a clear theme was the importance of showing the decision makers the environmental benefits in terms understandable for that region or area.

- Will arterial and freeway volumes and speed change? If so, by how much?
- · Will HC, NO and CO emissions change?
- · Will fuel consumption decrease?
- · Will the quality of flow be improved?
- What are the socioeconomic benefits?

Without definitive information, IVHS implementation can be stalled. The TSC is undertaking development of integrated models to assess IVHS impacts for Advanced Traffic Management Systems (ATMS), Advanced Traveller Information Systems (ATIS), and Advanced Public Transportation Systems (APTS). There is a need to include other technology groups such as CVO, ARTS, and AVCS in the model development process.

EIS, EA's Under NEPA

How Multimodal-IVHS projects are examined under the NEPA environmental process is unclear. However, IVHS has been included for site access EIS's/EA's and at the corridor level associated with other transportation actions. At the site level, multimodal-IVHS actions can aide TDM, TSM, and TCM actions which can reduce SOV use, thereby improving air quality, reducing energy consumption, and providing benefits. At the corridor level, IVHS can assist multimodal HOV actions organized to increase auto occupancy in the corridor.

The decision of whether or how to include IVHS in the environmental process is largely an administrative decision based on the lead and cooperating agencies involved.

CONCERNS TO BE ADDRESSED

The study and workshops have identified a number of concerns that need to be addressed before more meaningful evaluations can be made of IVHS's potential to improve the environment.

Comprehensive Evaluation Framework

There needs to be a comprehensive framework for evaluating IVHS projects that includes environmental considerations. Too often, environmental impacts are given only secondary consideration when evaluating potential IVHS benefits. A comprehensive framework of the type shown in Exhibit 2 that includes benefits (and costs) to air quality, the environment, the economy, and to society should be developed.

Reliable Data Sources

There is a need for more reliable data sources than are currently available. IVHS will be hard to sell at the state and local levels if there is not data to justify large expenditures on IVHS infrastructure and communication systems. Data from programs across the nation need to be consolidated and made available through a clearinghouse so that IVHS planners may have accurate data on which to base projections of benefits and costs.

Improved Modeling

The current models used to project impacts on air quality and the environment need to be updated to provide more accurate estimates of IVHS impacts. New models which take into account the wide range of potential IVHS impacts should also be developed.

Improved Operational Test Evaluations

There is a need for operational test data which can be **used** to assess the environmental effects of IVHS scenarios. Future operational tests must have evaluation programs that will yield reliable data. Appropriate measures of effectiveness should be developed to ensure that the data generated is meaningful and useful to transportation planners and engineers.

CONCLUSIONS

- IVHS Actions have potential positive environmental quality effects.
- When assessing environmental effects of IVHS, there needs to be a broad outlook to include social and economic effects in addition to traffic, air quality, energy and physical environmental effects.
- IVHS actions need to be incorporated into CMS, LRTP/TIP, and other processes where environmental concerns are addressed. It is difficult to assess IVHS as a stand alone action.
- A number of concerns need to be addressed including a data/finding clearinghouse function, better data, and better models.
- Priority needs to be given to scenarios with obvious environmental benefits including air quality alert, port/airport intermodal facilities, etc.

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 - 4. Bellomo, S.J., Air Quality Handbook, Prepared for FHWA, Vienna, Virginia, 1984.
- 5. Brand, D. "Criteria and Methods for Evaluating IVHS Plans and Operational Tests," presented at the 1994 Annual Meeting of the Transportation Research Board, Washington, D.C.

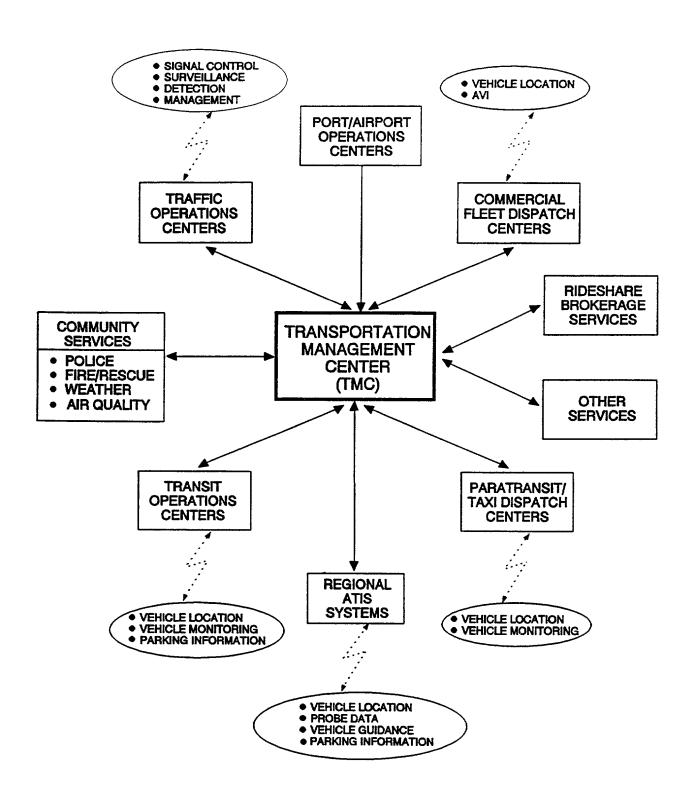


Exhibit 1. Transportation Management Center Concept

1. Applicability to Multi-Modal <u>Tranportation Management</u> - Criteria include:

- HOVRidesharing utilization
- Coordination with mass transit
- Applications to goods movement
- Compliance with Clean Air Act Amendments '90
- Compliance with the Americans with Disabilities Act

2. <u>Technical Feasibility</u> - Screening criteria include:

- Feasibility (need for new technology)
- Flexibility (alternate technologies)
- Reliability
- Expandability & upgradability

3. Potential Benefits - Criteria include:

- Reduced Single Occupant Vehicles
- Congestion reduction & avoidance
- Improve commercial vehicle productivity
- Pollution reduction
- improved transit/rideshare operations
- Improved safety
- Energy savings

4. <u>Potential Costs</u> - Criteria include:

- Implementation costs
- Operation & Maintenance costs
- Out of pocket user costs
- Non-monetary costs

5. <u>Institutional and Legal Issues</u> - Criteria include:

- Passenger security/safety
- Operator/manufacturer liability
- Need for inter-jurisdictional/interagency cooperation
- Opportunity for public/private cooperation
- Legal and regulatory restrictions

6. <u>Financial Feasibility</u> - Criteria include:

- Need for government subsidies
- Potential for commercialization
- User willingness to pay
- Applicability to existing funding programs

7. <u>Attractiveness to Users, Operators. and Society</u> - Criteria include:

- Acceptability to management
- Ease of learning system (users & providers)
- User and provider convenience
- Provision of incentives
- Impacts on non-users

6. Human Factors - Criteria include:

- Target audience
- Ability to gain larger user population
- Ease of use for all user populations
- Effectiveness in addressing human concerns

9. Potential for Success - Criteria include:

- Potential market penetration
- Long-term viability
- Integratability with other scenarios

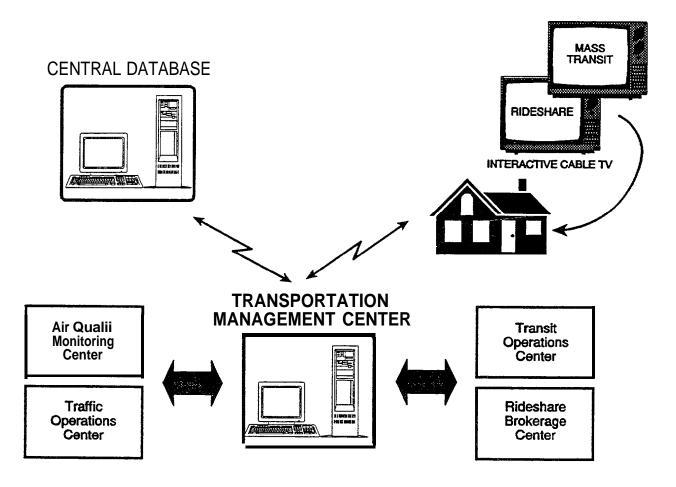
10. <u>Implementation Potential</u> - Criteria include:

- Barriers to deployment
- Compatibility with existing systems/modes
- Implementation sequence
- Areas of greatest potential impact (e.g. urban CBD, urban non-CBD, suburban, high activity centers, etc.)

Exhibit 2. Selected Evaluation Criteria

SCENARIO NO. 18 AIR POLLUTION ALERT

GOAL: Reduce mobile source emissions and encourage use of alternate modes during non-attainment periods.



SCENARIO

- 1. Air Quality monitoring center identifies non-attainment areas or forecasts potential air quality problems.
- 2. Persons within these areas are notified and presented with alternate travel modes.
- 3. Road pricing policies could be implemented using AVI equipment on cars.
- 4. Real-time travel data allows cities to adjust management strategies once they have been implemented.

Exhibit 3. Air Quality Alert Scenario

Summary Evaluation

Criteria Category	Summary Rating/Comment	Comments
Applicable to MM Transportation Management?	YES	Would permit implementation of multi-modal transportation controls to meet air quality attainment goals
2 Technically Feasible?	YES	Would largely use other IVHS systems to gain and disseminate information
3 Potential Benefits	нісн	Could help reduce mobile emissions and facilitate use of other modes
4 Potential Costs	MODERATE	If system uses existing IVHS infrastructure, additional costs should be moderate
5 Institutional/Legal Barriers	MODERATE	Will require regional (multi-jurisdictional) pollution control authority to coordinate mitigation measures
6 Financially Feasible?	YES	Services could be provided through other IVHS systems. Would not need to dedicate an entire system solely to this purpose
7 Attractiveness to Users, Operators, and Society	MODERATE	While mutigation measures themselves may be seen as unattractive, this system should be useful for users and operators during alerts
8 Human Factors Effectiveness	нісн	Will increase information available to travelers during alerts. Information will need to be accurate, timely, and accessible
9 Potential for Success	нісн	Should be a useful element of regional air quality plans. Could help to significantly reduce mobile source emissions
10 Implementation Potential	нісн	The CAAA '90 set out federal mandates to address air quality problems. This will be a major concern for non-attainment areas.

Exhibit 4. Conceptual Evaluation Scenario 18 -- Air Quality Alert

		MODE									
		PERSONS					GOODS				
SCENARIO	АСТО	HOV	TAX	1	RAIL	AIR	BIKE	PED	TRUCK	PORT	RAIL
MASS TRANSIT 1. Transit Route Deviation 2. Real-Time Bus Location information 3. Timed Transfer Management 4. Transit Park-Ride Information	ķ	×		X X X	x x x			X X			
5. Smartcard Fare Collection 6. Transit Priority on Information Displays 7. In-Vehicle Information Displays 6. Transit Schedule Reliability 9. tmprwed Transit Management Inlo.	x	x	x	XXXXX	X X X X	x	х	x			.,
10. Accident Data Recording PARATRANSIT & RIDESHARING 11. Real-lime Ridesharing 12 Paratransit Dispatching 13. Taxi Management WI Smartcard	X	X X X X	X	X X X	х				x		X
14. Urban Goods/Passenger Movement 15. Rural ATIS/RouteGuidance GENERAL HIGHWAY 16. Real-TimeTransportation Information 17. Needs Scheduling	x x x	x	x	x x x	X X				x	,	
18. Air Quality Alert 19. Weather/Roadway Condition Monitoring 20. ATIS - Parking Availability 21. Personal ATI.9 System 22. Traffic Management: at Parks/Monument	X X X	X X X	x x	X X X	x x x	x	x	x x	X X X		
AIRPORTS AND PORTS 23. Airport Access - Passenger Pick-Up 24. Truck Access to Ports/Rail 25. Vehicle Processing at Ports/Raill 26. River and Drawbridge Coordmation 27. Moving Urban Goods on Ferries:	x x	×		x		x			X X X	X X X	x x

Exhibit 5. Scenarios and Modal Applicability

	IVHS FUNCTIONAL AREA					U	RBAN ARE	A	
005/40/0						SUB-			
SCENARIO	ATMS	ATIS	APTS	cvo	AVCS	REGION	AREA	FACILITY	RURA
MASS TRANSIT	١	١	i	ŀ					
Transit Route Deviation	Х	X	X			х	х	X	X
Real-Time Bus Location Information	x	×	х			×	х	X	X
Timed Transfer Management	x	X	х	l	İ			X	ľ
4. Transit Park-Ride Information	х	x	X			х	Х		X
5. Smartcard Fare Collection	х		х		i :		х	x	x
6. Transit Priority on Signalized Networks	х		X			x	х		
7. In-Vehicle Information Displays	ł	X	Х				X	x	x
8. Transit Schedule Reliability	х	x	X					x	x
Improved Transit Management Info.		x	х	1	x	х	х	х	x
10. Accident Data Recording		х	х	х	х				
PARATRANSIT & RIDESHARING									
11. Real-Time Ridesharing	х	х	x			l x l	х		x
12. Paratransit Dispatching	x	х	x			l x l	x		х
13. Taxi Management w/ Smartcard		х	x	x			x		х
14. Urban Goods/Passenger Movement		х	x	X			x	ļ l	X
15. Rural ATIS/Route Guidance	×	X	x	х					х
GENERAL HIGHWAY									
16. Real-Time Transportation Information	x	x	x	x		x	x		х
17. Needs Scheduling	l x	x	x			l x l	х	1 1	x
18. Air Quality Alert	Ιx	х	х	x		x	X	l x l	X
19. Weather/Roadway Condition Monitoring	l x	х		x	l x l	x	x	l 🖁 l	x
20. ATIS - Parking Availability	Ιx	х		x		``	x	l x l	_ ^
21. Personal ATIS System	l x	x	x			x	x	^	х
22. Traffic Management at Parks/Monument		x	x			ı ^	••	×	^
AIRPORTS AND PORTS									
23. Airport Access - Passenger Pick-Up	x	x						l x l	
24. Truck Access to Ports/Rail	x	x		x				â	х
25. Vehicle Processing at Ports/Rail	x	â		â				â	×
26. River and Drawbridge Coordination	x	x		x			х	x	^
27. Moving Urban Goods on Ferries	x	x		x		_x	X	X	
27. Moving Urban Goods on Fernes					ــــــا			×	

Exhibit 6. Scenarios and IVHS/Area Applicability

			IVHS A	Action Groups		
	Increase Carpool	Increase Walk & Bike	Improve Paratransit & Goods Movement	Restricted Traffic	Pricing Measures	Parking Management
Increase Transit	С	A	A	А	A	А
	rease rpool	I	I	С	A	А
	Increase \ Bicy	11	1	A	I	I
		Improve I & Goods	Paratransit Movement	С	I	I
			Restricted Traffic		С	С
				Prici Measu		Α

Exhibit 7. Interrelationships Between Multimodal Action Groups

<sup>A - Action Groups assist each other.
I - Action Groups are independent of each other.
C - Action Groups are counterproductive to each other.</sup>

- For IVHS to be effective in reducing air quality there is a need to focus on parking availability and price. Volunteer efforts are ineffective during air quality episodes.
- Integrated Smart Cards covering mass transit, tolls, parking, congestion, pricing, etc. are needed to address reductions in emissions through SOV trip and VMT reduction. This will require a concerted partnership among the institutions.
- For mass transit to be effective in reducing SOV's, VMT, and emissions, there is a need to make it more customer oriented through improved mobility management (APTS) and driver training. AVL and AVI systems have been found to be effective in our management efforts.
- Nonrecurring congestion on freeways and arterials is a big part of the problem resulting in idling, emissions and wasted fuel. There is a need todevelop ATMS, ATIS and other IVHS infrastructure to address the problem. However, it (IVHS) will not work unless there are alternative routes with capacity to choose from.
- Since many of the environmental benefits of IVHS are subjects of various demonstrations and are uncertain, how can these projects be considered in LRTP, TIP and SIP developments at the State and Local level?
- For IVHS to be effective in improving environmental quality, IVHS related projects need to be integrated into plans and programs with conventional highway, transit, airport/port, ground access and other projects. It took us 8 years to get a signal implemented, how do we get our board to act on items in the research/demonstration stage?

When you look at the environment, think beyond the physical impacts (air quality, energy, congestion, traffic safety, etc.) to human factor effects (reduced anxiety and stress, improved driver/vehicle navigation, etc.). As IVHS makes better use of intrastructure, we have to account for new demands created, human factors, and socio-economic effects.

- We have trouble getting travel and environmental models (emissions, fuel consumption, etc.) to work with conventional plan and project evaluation. How do you get environmental models to work for real and semi-real time evaluations?
- Is there a clearinghouse to go to for reliable evaluation data and findings related to IVHS demonstrations and case studies? This is a particular concern for intermodal/multimodal projects.

Exhibit 8. Workshop Environmental Concerns

APPLICABLI Number	E OPERATIONAL TEST SITES Description	COULD BE TESTED SOON (FULLY)	COULD BE TESTED SOON PARTIALLY	MAY NEED NEW INFRA- STRUCTURE	NOTES/ COMMENTS
C-I-11	Fredericksburg ARTIS (VIRGINIA)		х	х	Needs to relate to VDOT.
A-II-4	Advance (Illinois)	х			NHTSA is cooperating.
A-II-5	Fast Trac (Michigan)			x•	NHTSA is cooperating.
C-I-5	TravLink (Minnesota)		х		Need outputs on initial project.
C-II-15	Portland SmartBus (Oregon)		x	x	Future Smart Vehicle projects could benefit.
C-II-16	Denver SmartBus Stage I (Colorado)		x	x	Future Smart Vehicle projects could benefit.
C-II-17	Baltimore SmartBus (Maryland)		x	х	Future Smart Vehicle project could benefit.
C-III-19	Ann Arbor Smart Intermodal (Michigan)		x	x	Future Smart Vehicle project could benefit.
C-III-20	Chicago Smart Intermodal (Illinois)		x	x	Future Smart Vehicle project could benefit.
C-I-12	Winston Salem Mobility Manager (N.C.)		x	х	
C-I-13	Delaware County Mobility Manager (Pennsylvania)		x	x	

COMMENTS

Presently only area where this is being done is C-I-11. There is not a lot going on in this area. Need to be more pro-active in promoting this scenario.

Modal administrations interested include FTA, FHWA, and NHTSA. The agencies are participating in the operational tests noted above.

*only arterial and collectors can be displayed in Fast Trac. Display and navigation for residential streets is required for this scenario.

A'- PRESENT OPERATIONAL TESTS (FHWA) C-APTS PROGRAM (FTA)

PLANNED OPERATIONAL TESTS D-

TRANSIT OPERATIONS OPERATING/PROCURING AVL

SYSTEMS

CORRELATION OF SITES WITH SCENARIO I.

Exhibit 9. Scenario Relationship to Operational Tests

	T
Traffic:	
SafetyVMTSpeed Congestion	 Reduced Accident Potential Reduced Trip Ends, VMT Reduced Idling, Improved Speeds, Managed Congestion
Physical:	
Cultural Resources	Reduced Tourist AnxietyImproved Pretrip Planning
Air Quality	Reduced Emissions, Concentrations Better Information During Episodes
 Noise & Vibration 	Reduced Truck Speeds
• Biota	• Less Construction. More Efficient Use of Facilities.
• Energy	• Improved Speeds, Reduced Fuel Consumption.
Social:	
Community Cohesion	Less Time in Traffic Jams. More time with community.
 Accessibility of Facilities and Services 	Better Real Time Responses for Police, Fire, Ambulance, and Other Services.
 Displacement 	Minimal Land Requirements.
Economic:	
• Employment, Income	New Technology and New Jobs.
Business Activity	More Predictable Passenger and Freight Movements. Increased Productivity.
Residential Effects	Minimal
Property Tax	• Unknown
• Resources	More Efficient Use of Resources.

^{*} Impression subject to verification and validation using demonstrative test results and acceptable environmental assessment models/procedures.

Exhibit 10. Potential Environmental Effects of Scenarios

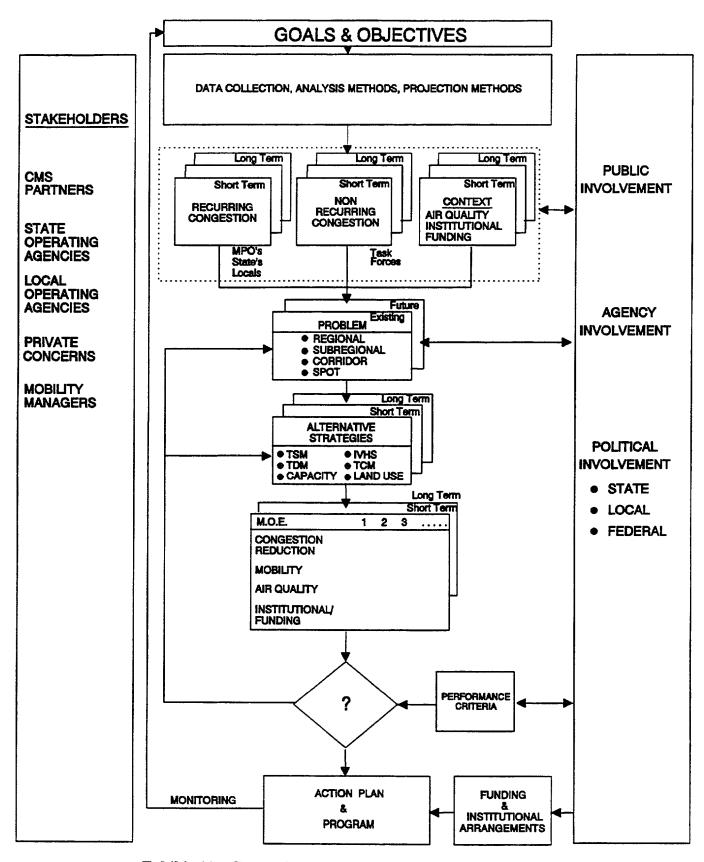


Exhibit 11. Congestion Management, Air Quality, and IVHS

CAPACITY-INDUCED INCREASES IN THE QUANTITY OF TRAVEL WITH SPECIAL REFERENCE TO IVHS

Sergio J. Ostria Don H. Pickrell Michael F. Lawrence

ABSTRACT

Many IVHSproducts and user services have been designed to alleviate urban traffic congestion by improving level of service and increasing vehicle throughput. There is concern that such improvements in the efficiency of the transportation system could lead to increases in travel demand and motor vehicle emissions. The cornerstone of arguments against IVHS deployment on the basis of air quality is the notion that increased roadway capacity will result in a new system with equal congestion but more vehicles and emissions. Some IVHS detractors argue that the detrimental effects of induced demand, manfested in increases in the number and length of vehicle trips, may outweigh the potential emission benefits of improved traffic operations and system efficienciesthat are brought about by IVHS. This argument, however, reflects a misunderstanding of the economic mechanisms leading to changes in the quantity of travel, as well as confusion between demand increases associated with induced traffic versus secular volume growth. The purpose of this paper is to present an analytical framework based on microeconomic principles for evaluating the potential impacts of IVHS on travel demand with emphasis on changes in consumers 'surplus and external costs.

BACKGROUND AND MOTIVATION

Intelligent Vehicle-Highway Systems (IVHS) have generated considerable enthusiasm in the transportation community as potential strategies to reduce highway congestion, improve highway safety, enhance the mobility of people and goods, and promote economic productivity in the country's transportation system. However, there is concern that while IVHS technologies alleviate congestion, resulting mobility improvements could lead to further increases in travel demand with the concomitant potential for increases in emissions. This concern stems from widespread community opposition to highway investments on the basis of the potential for "induced travel" and its associated external effects such as increased congestion, noise, air pollution, and energy consumption. Since the 1970's, environmental advocates have viewed highway investments, specifically road building, as causing a degradation in air quality because of the effect of induced traffic on trip generation and trip lengths.'

The potential for IVHS to improve level of service and increase vehicle throughput has generated a similar undercurrent of opposition to IVHS investments. Arguments against IVHS on this basis are often articulated as follows:

"A principal objective of IVHS -- to minimize total vehicle-hours of delay -- has little in common with the social imperative of reducing the environmental impacts of driving. The stated measurable goal for IVHS is to effectively double infrastructure capacity; these are the gains predicted for highly advanced technologies. Thus a successful IVHS program could effectively double (or significantly increase) vehicle-miles of travel assuming that total demand for travel is not fixed. And even if there is a theoretical saturation point for the number of automobiles and the number of trips taken, distances traveled have a tendency to increase as people and jobs move farther out to the suburbs and even back to more affordable rural areas."

The underlying economic principles behind travel demand and transportation supply have been largely ignored in the debate concerning the induced travel impacts of IVHS. But in order to evaluate the potential for induced travel from IVHS, it is necessary to understand the behavior mechanisms that lead to induced travel, as well as the different components that define changes in the quantity of travel. This latter issue is of special importance

since there seems to be confusion between travel growth that stems from induced travel, versus travel growth that is generated by demand increases in the rapidly growing areas or individual corridors where highway investments tend to be located. Therefore, it is critical to distinguish between increases in travel demand caused by decreases in *perceived user costs*, and increases in the quantity of travel caused by demographic and economic factors.

The central purpose of this paper is to present an analytical framework based on microeconomic principles for evaluating the potential impacts of IVHS on the quantity of travel, with emphasis on the resulting changes in consumers' surplus and external costs. A second objective is to identify the policy implications of these impacts. The paper is targeted to non-economists involved in the evaluation of the air quality and emission repercussions of IVHS or any other highway investment project.

AN ECONOMIC INTERPRETATION OF TRAFFIC VOLUMES

The first step in formulating the analytical framework is to review the interaction between transportation demand and facility performance (i.e., supply). The demand for transportation originates from the interaction among social and economic activities that are dispersed in space. Unlike most goods and services, transportation services are derived demands, meaning that in isolation travel seldom generates any measurable utility to the consumer. Rather, travel is an intermediate input to the consumption and production process.

When separated by space, individuals satisfy their needs for social and economic interaction by engaging in travel. In most urban areas, the production of trips is satisfied by three general modes of travel: motor vehicles, walking and bicycling, and mass transit. IVHS has the potential to influence all three of these modes but most predominantly motor vehicle and mass transit, which are the focus of this paper. While many of the concepts that are elaborated in this paper are applicable to commercial vehicle travel, this type of travel is not the focus of the analysis.

As with any other economic activity that consumes scarce resources, tripmaking involves a cost. Faced with alternative modes of transportation and routes from an origin to a destination, the consumer selects a mode and route on the basis of money cost, travel time, comfort, carrying capacity, and convenience. In the case of motor vehicle travel, money costs often include operating costs, such as gasoline, parking, vehicle repair, and toll costs, and ownership costs, such as vehicle depreciation and insurance. Costs associated with the time involved in undertaking a trip are referred to as the time costs of travel. These costs reflect an opportunity cost to the consumer, since the time devoted to travel could be used to generate income, participate in consumption activities, or engage in leisure. The perceived comfort and convenience of a given route or mode must also be accounted for in the total cost of tripmaking. These qualitative cost measures differ from one individual to another, and modes and routes are often differently rank-ordered by different consumers based on comfort and convenience, given an estimate of the associated money and time costs.

An important element in the derivation of the demand for travel is the effect of carrying capacity (i.e., facility performance) on perceived user costs. Congestion can be defined as affecting activities in which:

- motorists (i.e., consumers) supply some of the variable inputs (i.e., time, vehicles, fuel, etc.) required to produce travel (i.e., the service); and
- the required quantity of these inputs per unit of output, or the quality of the product itself (e.g., level of service), depend on the consumption rate.

As a given highway becomes congested, virtually every component of user cost increases. Money costs increase in proportion to fuel costs and vehicle depreciation (the wear and tear of stop and go driving). Comfort and convenience also decrease, but more importantly, time costs increase dramatically. As congestion worsens on a given facility, consumers respond to these rising costs by switching to alternative modes, routes, or times of travel. Thus, travel demand on the highway is inversely related to perceived user costs -- as costs increase, users demand less travel on the facility. Given a cost level, demand also varies based on income, population, and other variables that will be described later in the analysis.

Likewise, facility performance is influenced by the number of travelers using the system. In general, the supply function (i.e., facility performance) describes the level of service attributes that result from varying traffic volumes. Level of service attributes include those components of travel cost that are outlined above. The relationship between travel cost and the supply of transportation services is opposite to that of demand: while the demand function shows how traffic volume is affected by the level of service attributes of the transportation system, the supply function shows how these performance attributes are influenced by the traffic volume using the system.

The observed level of traffic on a highway or system reflects the interaction between travel demand and the performance of capital facilities (i.e., supply). As mentioned above, demand varies with the perceived prices or opportunity costs of user-supplied inputs necessary to produce trips. In turn, the quantity of user-supplied inputs, and thus the price to users of making trips, varies in response to traffic volume given a fixed complement of highway facilities.

The discussion presented above focuses on the general interaction between travel demand and supply. However, even the casual observer of traffic notices the differences in volume during different hours of the day and along different highways. Spatial and temporal variations in traffic volumes along individual corridors or on specific highways reflect the dynamic nature of the equilibrium between demand and supply. Traffic volumes on individual corridors and the utilization of specific facilities reveal the interaction between corridor- or facility-specific demand and supply functions. For a particular highway during a given hour of the day, a unique supply and demand relationship will prevail that determines the traffic volume on that highway at that time.

Various IVHS strategies have the potential to directly alter the interaction between demand and supply by changing the perceived user costs of travel. For instance, route guidance systems could decrease time costs by allowing users of the system to select the most expedient route from an origin to a destination. By diverting travelers from congested routes to free flowing routes, or less congested routes, geographic and temporal travel patterns may change, altering the global and local equilibriums between travel demand and supply that determine the performance of an entire transportation network. The remainder of this section derives the demand curve and supply curve for motor vehicle travel, in order to facilitate more detailed analysis of the impact of IVHS actions on facility performance and travel demand.

Characteristics of the Demand Curve for Motor Vehicle Travel

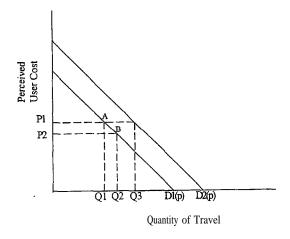
The quantity demanded of a good or service at different price levels -- holding constant all other determinants of demand, such as income, population, prices of all other goods, etc. -- is represented in economics by a demand curve. For most goods and services, the law of demand suggests that as price increases the quantity demanded of the good or service decreases. As a result, demand curves are usually downward sloping.

Exhibit 1 shows a hypothetical demand curve for motor vehicle travel -- drawn as linear in order to simplify the analysis. Perceived user cost is represented on the vertical axis and the quantity of travel (e.g., traffic volume, vehicle trips, vehicle miles traveled) on the horizontal axis. Unlike most goods, transportation is a derived demand, since by itself it does not produce any measurable utility, but rather serves as an intermediate service in the supply of labor or consumption of goods, services, and leisure. Because tripmaking permits individuals to participate in socioeconomic activities that generate utility or income, and because transportation is simply a means to overcome the spatial separation between residences and the locations of these activities, transportation is governed by the same microeconomic demand principles as all other normal goods. Specifically, and as depicted in Exhibit 1, as perceived user cost increases (as a result of either increases in money cost, time cost, or increased inconvenience), the demand for motor vehicle travel decreases.

Several basic features of the demand curve for motor vehicle travel should be noted. First, the demand curve depicts the functional relationship between travel and perceived user cost assuming that there is no change in the values of other pertinent variables such as the prices of complementary and substitute services (e.g., automobile travel versus public transportation), personal income, vehicle ownership, population, and other economic and demographic factors. Second, the demand curve depicts the situation at a single point in time and a specific

geographic location (e.g., a segment of a roadway, a corridor, a network, etc.). Hence, all but one of the user costs (prices) and travel quantities must be hypothetical -- the curve must generally answer the "iffy" question: "If **price** were to change, how much travel would be demanded by an individual or set of individuals)?" Third, changes in perceived user costs cause movements along the demand curve (depicted in Exhibit 1 by the movement from point A to point B). Corresponding changes in the quantity of travel demanded (i.e., depicted in Exhibit 1 as the change from Q_1 to Q_2) represent what has been referred to as "induced demand." (It should be noted that "induced demand" is not a term used in economics since the entire area beneath the demand curve represents potential demand. Price simply determines the level of demand throughout the demand function.)

Fourth, changes in the price of complementary and substitute goods, personal income, vehicle ownership, population, or other economic and demographic factors cause the entire demand curve to shift, so that either more or less travel is demanded at any given price. For example, an increase in population (in a particular region) causes the demand curve (for that region) to shift outward to D_2 as shown in Exhibit 1.



It is important to distinguish between increases in travel associated with changes in perceived user cost and increase resulting from changes in economic and demographic factors.

A decrease in price from PI to P2 causes an increase in the quantity of travel of Q2-Ql. This change in travel is what has been termed as "induced demand."

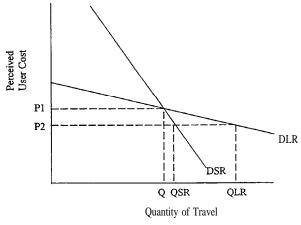
An increase in personal income, for example, causes the entire demand schedule to shift from DI to 02 so that at PI the quantity is now Q3. The difference, Q3-QI, secular growth.

Exhibit 1 Demand Curve for Road Travel: Induced vs. Secular Growth

This shift generates an increase in the quantity of travel from Q, to Q3 that is generated by secular growth rather than by a reduction in price. It is important to distinguish between increases in travel caused by decreases in price, and increases in travel stemming from demand increases in the rapidly growing urban areas or individual corridors where highway investments tend to be located. Finally, the magnitude of changes in demand in response to changes in price is summarized by the elasticity of demand. Elastic demand (represented by a relatively flat demand curve) implies that a change in price leads to large changes in quantity. Inelastic demand (represented by a relatively steep demand curve) implies that a change in price leads to only small changes in quantity. In the short run, the demand curve for travel is relatively inelastic, since travelers cannot readily alter the travel demands that result from their existing housing and employment locations. As a result, changes in price have a relatively smaller impact on travel demand. In the long run, however, households have the capability to select different housing and employment locations and to alter their behavior in other ways that influence their travel behavior. Therefore, the long-run demand curve for travel is more elastic than the short-run demand curve, and changes in these patterns are not embodied in the short-run demand curve. Exhibit 2 graphically depicts this relationship.

Consumers' Surplus

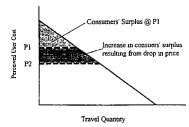
Individuals engage in travel so that they can participate in socioeconomic activities that generate income or utility. In economics, the benefits of consuming a good or service are represented by *consumers' surplus*. Consumers' surplus is defined as the net benefit that consumers get from being able to purchase a good at the prevailing price, measured by the difference between the maximum amounts that consumers would be willing to pay and what they actually do pay. As depicted in Exhibit 3, consumers' surplus is represented by the triangular area under the demand curve and above the prevailing market price (e.g., P_i). Changes in the market price for travel (i.e., the perceived user cost) alter the magnitude of consumers' surplus. For example, decreases in travel time that result from highway investments, such as advanced traffic management systems or capacity expansion, lower total user cost, represented in Exhibit 3 by the fall in price from P_1 to P_2 . The fall in price results in increased benefits to the system's users, depicted by the increase in consumers' surplus. Therefore, insofar as analyzing IVHS projects in this manner indicates that they are likely to induce traffic growth, they will also produce benefits to users of the system or roadway. Determining the net effect of changes in externalities associated with increased travel and increases in consumers' surplus requires the incorporation of the supply curve for travel into the analytical framework, which is the subject of the following subsection.



Short-run demand is relatively inelastic when compared to long-term demand. In the short run, travelers cannot easily alter housing location nor travel behavior so that changes in use cost have a relatively smaller impact on travel demand. For example, as price falls from PI to P2, the effect on long-run demand is much greater (i.e. QLR-Q>QSR-Q).

Land use patterns are represented by the long-run demand curve, when businesses and/or households can alter location decisions.

Exhibit 2
Short-Run vs. Long-Run Demand and the Role of Land Use



Consumers' surplus represents benefit to users (i.e. consumers) of the transportation system. Investments that decrease user cost increase consumers ' surplus as depicted above.

Exhibit 3 Consumers' Surplus

Derivation of the (Short-Run) Supply Curve for Motor Vehicle Travel

Microeconomic theory defines the supply curve as a function that provides the quantity of a good that a seller is willing to offer in a market at each given price. The higher the price, the more of the good that the seller is willing to offer. While this definition is adequate for many goods and services, it is not well suited for analyzing travel supply. This inadequacy largely stems from the fact that much of what determines the attributes of travel supply is a result of user rather than supplier behavior. As discussed above, facility performance is directly determined by how travelers use the transportation system. Thus, many of the important aspects of transportation level of service that directly affect traffic flows depend on user behavior, rather than on decisions made by a supplier or operator. In deriving the short-run supply curve for travel, the following measures, which define the operational state of any given traffic stream, must be considered:

- *Speed*, defined as the rate of motion expressed as distance per unit of time, usually expressed as miles per hour (mph);
- *Traffic Density*, defined as the number of vehicles occupying a given length of a lane or roadway, averaged over time, usually expressed as vehicles per mile (vpm); and
- *Traffic Volume*, which measures the quantity of traffic passing a point on a lane or roadway during a designated time interval, usually expressed as vehicles per hour (vph).

Travel time, or the reciprocal of speed, is an important measure of the quality of traffic service provided to the motorists. It is one of the more important measures of level of service for many types of facilities. As a result, speed is an important component of facility performance and perceived user cost which determines driver behavior.

Traffic density is a critical parameter describing traffic operations, since it reflects the proximity of vehicles to one another. Vehicle proximity can be measured by *spacing*, or the distance between successive vehicles in a traffic stream as measured from front bumper to front bumper. As speed increases, spacing increases (usually at a decreasing rate) because drivers require longer following distances. The time between successive vehicles as they pass a point on a lane or roadway is defined as *headway*, which is also a function of speed. Empirical evidence suggests that vehicles do not travel at constant headways; rather, they tend to travel in groups, or platoons, with varying headways between successive vehicles.⁶ As a result, these phenomena also depend on driver behavior, specifically the rules that motorists follow to determine a safe following distance.

Mathematically the relationships between speed, following distance, and traffic density are expressed below.

```
H = G/S (Equation 1) where:
```

H = headway, in seconds per vehicle;

G = spacing (or the gap between vehicles), in feet per vehicle; and

S = the speed of the second vehicle in a given pair of vehicles, in feet per second.

Rearranging this equation, we see that spacing is given by G = H * S.

```
D = 5.280/G (Equation 2) where:
```

D = traffic density, in vehicles per mile;

5,280 represents the number of feet in a mile; and

G = spacing, in feet per vehicle.

Since spacing is itself a function of speed, traffic density also depends on speed. Specifically, as speed increases, traffic density decreases at a decreasing rate. The relationships among speed, following distance, and traffic density are depicted graphically in Exhibit 4.

Traffic volume is given by

V = S * D (Equation 3) where:

V = rate of flow, in vehicles per hour (vph);

S = average travel speed, in miles per hour (mph); and

D = traffic density, in vehicles per mile (vpm).

Given the expression for traffic density and headway, we can show that traffic volume can be expressed as follows:

$$V = (5280 * S)/G$$
 (Equation 4)

Note that G, or the distance between successive vehicles in a traffic stream, increases with speed. Given the correct functional relationship between spacing and speed, the interaction between traffic volume and speed takes the form of that shown in Exhibit 5. Note that a zero flow rate occurs under two very different conditions:

- 1. When there are no vehicles on the facility, the rate of flow is zero since density is zero.
- 2. When density becomes so high that speed converges to zero (total gridlock), the rate of flow is also zero. The density at which all movement stops is referred to as *jam density*.

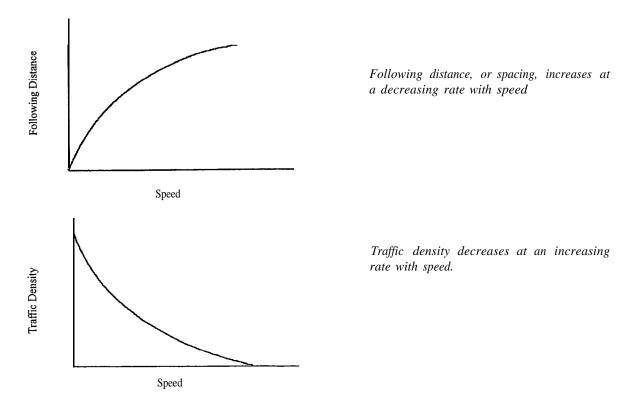
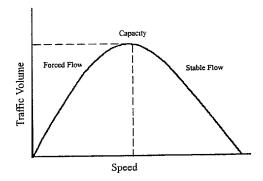
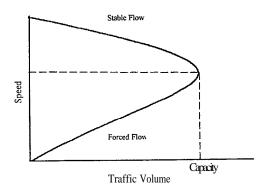


Exhibit 4

Derivation of the Supply Curve for Road Travel: Spacing and Density as a Function of Speed



The maximum rate of flow is reached when the product o f increasing density and decreasing speed results in reduced jlow.



inverse of volume-speed relationship gives conventional backward bending speed-volume curve.

Exhibit 5

Derivation of the Supply Curve for Road Travel:
Traffic Volume -Speed Relationship

As density increases from zero, the rate of flow also increases as additional vehicles enter the roadway. Due to the interaction of vehicles, speed begins to decline as flow increases (i.e., we move backwards on the spacing-speed curve shown in Exhibit 4). As more and more vehicles enter the traffic stream, a point wili soon be reached where with further increases in density, speed is reduced so much that the flow of vehicles declines.' The maximum rate of flow, or capacity, is reached when the product of increasing density and decreasing speed results in reduced flow. Therefore, any rate of flow other than this maximum capacity can occur under two different conditions -- with high speed and low density, or with high density and low speed.' Conditions characterized by high-density and low-speed reflect roadway congestion; points to the left (or to the south) of the maximum flow on Exhibit 5 reflect congested conditions.

The translation of the speed-volume relationship depicted in Exhibit 5 into the supply curve for travel involves the dependency of perceived user costs on travel time (i.e., the reciprocal of speed). Realizing that travel time per unit of distance (e.g., minutes per mile) is given by the amount of time spent traveling (such as 60 minutes) divided by speed (miles per hour), the cost of travel time per unit of distance traveled can be represented as:

c=t * v. where:

c = travel time cost per unit distance, in cents per mile;

t = travel time per unit distance, in minutes per mile; and

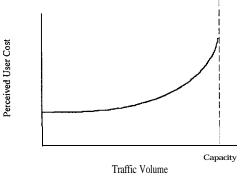
v = value of time, in cents per minute.

Total perceived user cost (TC) per unit distance traveled is then given by the following expression:

$$TC = OC + c$$

where OC represents vehicle operation cost. Since c is a function of speed -- as speed decreases c increases -- perceived user cost also increases as speed decreases.

The resulting relationship between the cost per unit of travel (marginal cost) and volume is depicted in Exhibit 6. As volume increases, marginal perceived user cost increases slowly at first, but as volume approaches its maximum rate of flow, marginal perceived cost begins to increase very rapidly. This relationship describes the short-run travel supply curve, which shows the quantity of travel services that can be accommodated by a facility (or corridor, region, etc.) at various levels of marginal perceived personal cost. Quantity of travel can be represented by a number of measures, including traffic volume, number of vehicle trips, vehicle miles of travel, and others. Supply functions that represent a system with fixed capacity are referred to as *short-run functions; when the* capacity of the system is expanded as the output level increases, then the resulting cost function is referred to as a long-run supply function.4



As volume approaches its maximum flow rate (i.e., capacityl, perceived user cost increases rapidly.

Exhibit 6 Supply Curve for Road Travel

In summary, perceived user costs are critical to driver behavior including mode and route choice. For a particular trip, the supply function for passenger travel is therefore commonly dependent on the following user cost parameters.

Total money cost. In addition to vehicle operation costs, such as fuel, parking and vehicle depreciation costs, out-of-pocket costs include implicit costs such as indirect taxes. The potential effect of IVHS implementation and operation on the out-of-pocket aspect of travel has largely been ignored in the debate concerning induced travel from IVHS deployment. Yet highways are operated under the *user pays principle*, and there is no clear evidence that the implementation and operation of IVHS will not result in increased out-of-pocket costs through changes in excise taxes to support the Highway Trust Fund and state and local highway funding.

Total travel time. This cost element involves opportunity costs associated with access time, waiting time, transfer time (applicable to transit), and line-haul time (time actually spent in motion). Many IVHS products and user services will reduce total travel time by decreasing recurrent and nonrecurrent congestion. For example, traffic signalization systems allow vehicle movements to be controlled through time and space segregation, speed control, and advisory messages. Advances in traffic signalization involve the incorporation of real time data on network capacity and demand, thereby facilitating the optimization of network efficiency and reducing delays associated with congestion.

Other parameters accounted for by the supply function include comfort and convenience. The discomfort and inconvenience of travel will be alleviated by many IVHS strategies, such as advanced vehicle control systems that will eventually remove, or minimize, the human element from the vehicle operation process.

These attributes of the supply function suggest that even a facility with fixed physical capacity has a supply curve associated with it, and congestion (resulting from changes in driver interaction behavior with travel speed) causes these supply curves to be upward sloping. The steepness (i.e., elasticity) of the supply curve as congestion

sets in depends on driver behavior. The influence of a facility's physical design on traveler behavior determines the sensitivity of travel cost to changes in the quantity of travel services. The effect of IVHS on travel supply will depend on the cumulative impact of IVHS on travel cost, often as a result of associated decreases in travel time.

External Costs

Externalities in the form of congestion, air pollution, noise, and other disamenities are generated by motor vehicle travel, so that the private cost of a mile of urban travel is often significantly less than its full social cost. Congestion is a societal as well as a private problem. By entering a congested traffic stream, an individual motorist not only increases his/her own private cost, but also increases the private cost of other motorists on the roadway. Therefore, congestion costs are a form of externality -- the action of one individual imposes costs on others in addition to those he/she bears.' The quantification of this component of social cost is a difficult task but can be measured directly as increased travel time, or indirectly by losses in productivity or economic output.

Noise and air pollution are other disamenities associated with motor vehicle travel that cause divergences between private costs and social costs. Both of these phenomena worsen with increases in road travel. While the measurement of these external costs depends on the societal value placed on cleaner air, for example, these and other external costs can nevertheless be calculated in abstract. For illustration purposes, assume that the cost of motor vehicle travel is given by the following expression:'

```
TC,,-, = [M*C*(n-1)/S] + [M*k*(n-1)] where:

TC = the total cost of motor vehicle travel,

A4 = the length of the facility,

C = the marginal cost of travel per unit of time.

k = the noise and air pollution costs per mile driven,

S = the average travel speed, and

n-l = the number of travelers originally on the facility.
```

Assuming that as soon as an additional driver enters the traffic stream (increasing the number of travelers on the facility from n-l to n), the average speed per vehicle will fall by X as a result of congestion, total cost will change as follows:

```
TC_{n} = [M*C*n/(S-X)] + [M*k*n] where X is positive, but smaller than S.
```

Therefore, marginal social cost. or the additional cost imposed by the *nth* motorist, is simply the difference between TC_n and TC_n , given by:

$$MSC$$
,= $[M*C*n/(S-X)] + [M*k*n] - [M*C*(n-1)/S] + [M*k*(n-1)]$
= $[M*C/(S-x)] + [M*C*X(n-1)/S(S-a] + [M*k]$

To any individual motorist, the marginal private cost of travel is given by (recall that motorists do not directly bear the costs represented by k):

$$MPC_{\cdot,\cdot} = M*C/(S-X)$$

The difference between marginal social cost and marginal private cost defines the *external cost*. In our simplified example, external cost is given by:

$$MSC_{,,} - MPC_{,,} = [M*C*X(n-I)/S*(S-X)] + [M*k]$$

By construction, X, M, C, k, n-l, S, and S-X are positive. So, the expression for external cost is positive and the nth individual imposes an additional cost to society by entering the traffic stream. Graphically, this difference is depicted by the vertical distance between the MSC curve and the MPC curve as shown in Exhibit 7.

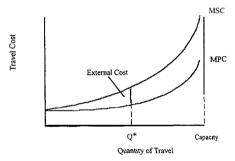
The comparative magnitude of their effects on consumer surplus and external costs determines the societal value of deploying IVHS technologies, products, and user services.

The Equilibrium Quantity of Travel

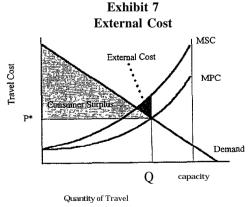
The interaction between travel demand and travel supply determines the observed level of traffic on a system at a given point in time. Exhibit 8 graphically demonstrates this interaction. Shifts in either the demand or the supply curve will establish new equilibrium levels of both the quantity of travel services (i.e., volume, vehicle trips, vehicle miles traveled, etc.) and the price per unit of those services (i.e., dollars per trip, cents per mile, etc.). The relative magnitudes of supply and demand price elasticities determine the response of the equilibrium level of travel and its associated cost to changes in demand or supply. Shifts in supply are commonly associated with capital investments that increase the quantity and/or quality of the road infrastructure, while shifts in the demand curve are brought about by changes in economic and demographic factors (as discussed earlier). The potential impact of some IVHS products on facility performance, travel demand, and the equilibrium quantity of travel is the subject of the following section.

POTENTIAL IVHS IMPACTS ON THE QUANTITY OF TRAVEL

Many IVHS technologies, products, and user services can be analyzed within the travel demand and supply framework that has been described above. For instance, advanced vehicle control systems will affect the response of driver interaction behavior, such as following distance, to variations in travel speed. Changes in the following distance-speed relationship will translate into changes in the other relationships that determine facility performance (i.e., travel supply). Other systems that improve the quality and reliability of travel information will affect travel demand by altering the departure profile of trips and route selection.



External cost at quantity of travel Q^* is given by the difference between marginal social cost (ABC) and marginal private cost (MPC).



The equilibrium quantity of travel (i.e., observed traffic volumes) at a given point in time along a specific route or entire system is given by the interaction between travel demand and supp[v.

Exhibit 8 Equilibrium Quantity of Travel

An example of the effect of an IVHS strategy on the quantity of travel is depicted in Exhibits 9 and 10. Automatic headway control systems. for instance, employ vehicle sensors to maintain constant distances between vehicles traveling in a particular lane or highway. Distance monitoring is combined with brake and speed control in order to decrease following distance and increase vehicle throughput. Therefore, the implementation of these systems will change the following distance-speed relationship depicted in Exhibit 4, by decreasing the spacing between vehicles for any given travel speed. This effect, as shown in Exhibit 9, can be represented by a downward shift in the following distance-speed curve so that at any particular speed (other than zero), shorter following distances will prevail Decreases in spacing will also impact traffic density: as spacing decreases for any given speed, density increases, thereby shifting the density-speed curve outward to the right. The end result will be a downward shift in both the private and social cost curves that are shown in Exhibit 7 so that facility performance (supply) increases at every user cost, while external costs (the difference between MSC and MPC) declines at every traffic volume.

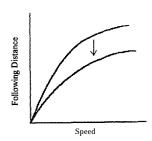
When combined with the travel demand curve for that lane or roadway (at a given point in time), the effect of the shift in supply translates into a new equilibrium quantity of travel as demonstrated in Exhibit 10. The increase in travel reflects induced traffic resulting from decreases in marginal user costs, or the increase in facility utilization that is prompted by the resulting reduction in the user cost per unit of service that the facility provides (e.g., cents per vehicle-mile traveled on the facility at a point in time). Several observations are in order:

- Induced demand should be regarded as an indication that an investment such as IVHS is generating benefits, rather than as evidence of an unforeseen or unintended side-effect that can only be avoided by eliminating the investment. As shown in Exhibit 10, at the new equilibrium quantity (Q*) and marginal perceived user cost (P*), consumers' surplus is larger. The magnitude of the change in consumers' surplus depends on the relative elasticities of supply and demand. Therefore, where travel growth induced by the deployment of IVHS projects generates external costs, it also produces substantial benefits to users of the transportation system.
- Where travel growth induced by IVHS deployment produces external costs, it is important to deal with externalities directly (e.g., by improving emissions technology, increasing gasoline taxes, implementing road pricing, etc.), rather than to sacrifice the benefits of investment in order to minimize these external costs. At the very least, the benefits of an IVHS action should be weighed against any resulting change in the external costs generated by travel on the improved road segment.

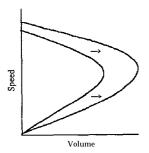
Moreover, induced demand resulting from the deployment of IVHS should be distinguished from increases in travel and facility utilization that originates from secular growth. The dynamic nature of the market for motor vehicle travel is represented by continuous shifts in demand that result from secular growth, and by periodic increases in supply -- through either capacity expansion or, in the future, IVHS deployment -- as depicted in Exhibit 11. Induced demand is associated with reduced user cost since the outward shift in the supply curve implies that more travel can be accommodated at every level of cost. Outward shifts in the demand curve result in higher user costs --since as congestion sets in, speed decreases and travel time increases. In practice, increases in supply are often undertaken in exactly the places where demand is growing most rapidly, which creates difficulties in separating the component of observed travel growth resulting from demand growth from the component that is induced by increases in supply. Finally, at the level of an individual facility, much of what is referred to as induced demand actually may be traffic diverted from competing facilities (or modes), rather than newly induced traffic.

Although the microeconomic framework that has been described in this analysis has focused on the potential effects of improved traffic flow on the quantity of travel, it is also useful for analyzing the impacts of trip planning, mode choice, and other travel parameters. For instance, advanced traveler information systems address inefficiencies resulting from imperfect information by assisting motorists in their decision-making processes regarding trip route, trip mode, trip time, and the other aspects of trip planning. Imperfect travel related information is currently partly responsible for wasteful vehicle miles traveled and tripmaking contributing to system inefficiencies and congestion, increased air pollution, and increased energy use. An important element of advanced traveler information systems

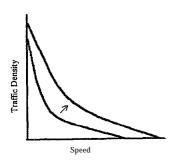
is the provision of improved information prior to trip departure. For example, electronic route planning systems link minimum path computer algorithms -- which may be based on trip length, trip time, or trip cost -- to surface transportation network data bases to assist travelers in determining the optimal trip departure time, route, and mode.



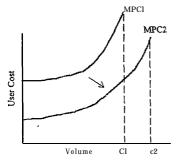
a) Deployment of headway control systems allows decreases in spacing without changes in speed.



c) Effect on density increases potential volume at given speeds and capacity. throughout capacity.

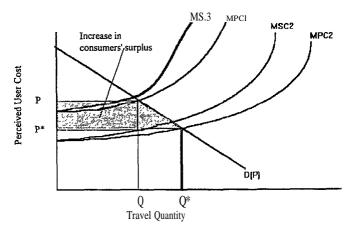


b) Translates into increased density at all speeds.



d) End result is a decrease in user costs and shift of supply curve, increasing

Exhibit 9 Example Effect of IVHS on the Determination of Supply

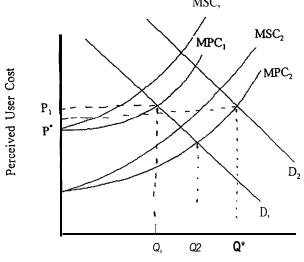


Development of automatic headway control systems, for example, reduces the equilibrium price and increases the equilibrium quantity. The fall in price generates an increase in consumers' surplus.

Q*-Q represents 'induced" traffic resulting from development of technologies,

Exhibit 10 Sample Impact of IVHS on the Equilibrium Level of Travel

The potential impact of advanced traveler information systems, such as electronic route planning, on the quantity of travel is depicted in Exhibit 11. The implementation of these IVHS strategies will affect both the information and transportation "markets." First, system deployment will increase the supply of travel information, depicted in Exhibit 11 by an outward shift in the information supply curve (shown here as linear). Increases in the quantity of travel information will lead to a fall in the price of information from Po to P., thereby directly impacting the transportation market as travelers adjust travel plans to take advantage of less expensive and more reliable trip information.



Quantity of Travel

Initially, equilibrium is given by P,, Q,. As demand increases (i.e., shifts from D, to DJ, supply increases to accommodate the secular growth. The end result is a new equilibrium level of travel given by Q^* . Q^2 -Q, is the induced component of travel growth, while Q^* - Q^2 is the growth in travel associated with secular growth.

Exhibit 11 Simultaneous Shifts in Demand and Supply

One type of adjustment that travelers may undertake is to alter trip departure time. Assuming that some travelers have the ability to change the departure time of work related trips, the impact of systems such as electronic route planning will be to increase the demand for off-peak period travel and decrease the demand for peak period travel. The effect of changes in departure time on the quantity of peak and off-peak travel is depicted in Exhibit 11 by an inward shift in the demand curve for peak period travel (i.e., a shift from D_p^0 to D_p^1) and an outward shift in the demand curve for off-peak travel (i.e., a shift from D_{op}^{-1} to D_{p}^{-1}). The net effect on motor vehicle emissions depends on the magnitude of the shift from peak to off-peak travel. It is probable, however, that the implementation of pretrip planning information systems will decrease congestion during the peak period without significantly curtailing traffic flow during the off-peak period, since only a subset of workers will be able to alter their trip departure times. Improving traffic flow during peak periods will reduce emissions and energy consumption, all other things being equal.

POLICY IMPLICATIONS

This paper has presented an analytical framework for evaluating the potential effects of IVHS products and user services on the quantity of travel. IVHS will undoubtably have supply effects as a result of improvements in level of service that may result from more efficient traffic operations, reduced congestion, and better interface between the road and the vehicle. What has been termed as the induced demand repercussions of IVHS is simply represented by a movement along the demand curve for travel that results from reductions in perceived user costs in response to increases in facility performance (i.e., supply). Although it is true that many IVHS strategies will

decrease user cost and thus increase travel, any external costs generated by this increased travel must be weighed against the benefits that are accrued by users of the system. Policies that discourage highway investment projects (e.g., advanced traffic management systems) in an attempt to minimize externalities of motor vehicle travel forgo opportunities to improve social welfare by restricting potential increases in consumers' surplus. It is important to implement policies that directly deal with external costs, rather than to forgo potentially valuable investments simply because they may generate some increase in external costs.

To this end, various IVHS technologies are also well suited for enhancing the effectiveness and logistics of transportation demand management programs, such as road pricing, that can help to internalize the external costs associated with motor vehicle travel. IVHS can play an integral role in programs that attempt to change the price signals sent to users of the transportation system. Through automatic vehicle identification, for example, fees can be set to vary over time and distance so that higher charges at peak periods and over longer trips can compensate for the higher congestion and environmental costs of peak period and long distance travel.

Similarly, on-board diagnostics, that monitor a vehicle's emissions, and remote sensing devices, that measure exhaust pollutants from moving vehicles, are examples of IVHS technologies that can facilitate the identification, repair, or removal from service of super-emitting vehicles and that can supplement conventional control strategies such as inspection and maintenance programs. In this manner, policies that directly address external costs can be formulated with the assistance of IVHS.

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USER ACCEPTANCE OF IVHS: AN UNKNOWN IN THE ENVIRONMENTAL EQUATION

Carol A. Zimmerman Battelle

Intelligent Vehicle-Highway Systems (IVHS) have been characterized as both a boon and a bane to environmental quality.' On the one hand, proponents see IVHS as a means to achieving a more efficient transportation system that will lead to less wasted fuel and fewer vehicle emissions. On the other hand, a fear of latent travel demand unleashed by IVHS-improved traffic flows has others doubting the long-term benefits. Still others see environmental promises being realized if IVHS is applied to manage travel demand through road pricing, modal shifting and other such measures which employ IVHS technology.

Running through this debate are assumptions, expectations, and projections about the users of IVHS technologies. These IVHS users will, by virtue of the travel behavior they exhibit, have an impact on environmental quality. Despite this fundamental linkage between users and the environment the truth is that a good picture has yet to be painted about IVHS users. Basic questions remain unanswered, such as how many people will use IVHS technologies, how will they change their travel behavior, what motivates those changes, and what are the impacts of those changes on environmental conditions?

This paper examines the role that one set of users, individual travelers, plays in the assessment of IVHS and the environment. First discussed are points of entry for IVHS in travel decisions. Next, a selection of research to date is examined for the likelihood of penetration of IVHS technology and services among traveler markets. In the final section, observations are made on implications for the marketing of IVHS among travelers and how that activity plays into the environmental equation.

IVHS TECHNOLOGIES AND TRAVEL DECISIONS

IVHS has the potential to enter into travelers' decision-making at several points in the decision process. A useful framework capturing those relationships has been presented by Shladover. Figure 1 represents a modification of Shladover's framework for the purposes of this paper.

The demand for transportation arises from an individual's desire to satisfy certain needs (economic, social, recreational, etc.) that can be met at another location. In the long run an individual may reduce or eliminate the spatial separation of desired locations by such means as changing jobs or relocating his or her residence. In the near term, other factors come into play that determine whether a trip takes place and the characteristics of that trip. Travel behavior research has shown that individual and household characteristics such as employment status, gender, residential location, and household structure are important determinants to number, length, and mode of trips.

While traditional travel behavior research has helped to identify the underlying structural determinants of travel demand, the application of IVHS technologies and services takes a dynamic view of tripmaking. In this view an individual has the opportunity to consciously decide whether, when, where and how each trip is made. The technologies of communications and information processing, upon which IVHS is based, enable this constant reassessment process to take place.

IVHS technologies and services can come into play in an individual's travel decision-making in several ways. As shown in Figure 1, and described in the following section, IVHS points of entry are represented by the following boxes:

Substitution of telecommunication alternatives Demand management policies Pre-trip travel information En-route travel information The end result of the trip-making process shown in Figure 1 is a trip and, with it, all the environmental effects that trip entails. There are several potential environmental benefits of a traveler's use of IVHS services that results in a change in trip-making behavior:

IVHS-BASEDTRIP-MAKING CHANGE	ENVIRONMENTAL IMPACT
avoidance of traffic congestion & stop/go traffic	improved fuel efficiency, reduced emissions
efficient routing	fewer vehicle miles of travel
elimination of trips	fewer vehicle miles of travel
increase in persons per vehicle	fewer VMT/person

This paper looks at the traveler's decision-making process, how IVHS fits into it, and reviews a selection of research to date that suggests how soon IVHS-based travel changes and their environmental impacts are likely to be realized.

USE OF IVHS IN TRAVEL DECISIONS: WHAT RESEARCH HAS SHOWN

Substitution of Telecommunication Alternatives

The first decision a potential traveler has to make is whether to travel at all. Increasingly, travelers are being offered opportunities to substitute telecommunications for trip making in overcoming the spatial separation between traveler and the desired destination. Telecommuting to work, distant learning for education, and teleshopping are some examples of how individuals can substitute the capabilities of telephones, televisions, facsimile machines, and data modems for the trip to work, school, and store.

Certainly eliminating trips altogether has the greatest positive impact on the environment. How significant an impact are telecommunication substitutions likely to have? The answer appears to be a limited amount, based on current trends. Data cited by Hopkins et al.⁴ indicate that, while positively perceived by workers, telecommuting will be used by less than 5% of the labor force by 1997. Moreover, in one study they cite, even among employees who had tried telecommuting. the attrition rate was high (33%). In the Los Angeles area, a survey of workers in 1993⁵ found that while 90% took advantage of the opportunity to telecommute a few days each month, only 10% actually had been given that opportunity.

The behavior described in these studies suggests that telecommuting will continue to have a persistent but modest effect on work trips and hence on their environmental impact. Additional impacts may be realized if telecommunication substitutions become significant for shopping education, and leisure-time pursuits, as proponents of the Information Superhighway are envisioning. Until then, substitution of telecommunications for trips is unlikely to be very great.

Demand Management Policies

Once an individual makes the decision to travel, demand management policies represent the next opportunity for IVHS to affect travel behavior. IVHS technologies enable traffic managers to apply incentives and enforce regulations aimed at smoothing traffic flow and optimizing the transportation network. For example, technologies such as automatic vehicle identification, electronic payment, personal telecommunication devices, software and databases facilitate implementation of congestion pricing plans and programs to reduce the number of single occupancy vehicles through use of HOV lanes, ridesharing/ridematching programs. and modal shifts to transit.

Has research to date indicated how effective the application of IVHS to demand management will be in getting people to change their trip making behavior? While the literature on congestion pricing is scant, one study⁶

based on data on tolls at the Golden Gate Bridge indicates that pricing can reduce traffic during peak periods. Either modal shifts occurred or travelers gave up trips altogether; the data are silent on this point. Getting people out of their single-occupant vehicle represents perhaps the greatest challenge for IVHS. One study, based on a survey of Virginia commuters, found that casual carpooling (a.k.a. dynamic ridesharing) was projected to attract 18% of Beltway commuters, if time savings for both driver and passengers were a prerequisite. On the other hand, a test of a dynamic ridematching service in Bellevue, Washington, has found more people offering rides than accepting.' Koppelman et al.⁸ found in suburban Chicago, that direct disincentives for single occupancy vehicles need to be combined with incentives for ridesharing to produce substantial increases in ridesharing. For example, fees at employee parking lots were needed to equalize the relative attractiveness of transit and van pools with driving alone.

While these data are far from conclusive, one might speculate that IVHS-based demand management will need to rely heavily on economic signals to induce significant changes in trip-making behavior. such as time or mode changes. Ridesharing in the abstract may sound attractive to travelers. even with dynamic ridematching that IVHS enables, but observed behavior suggests major hurdles must be overcome for it to succeed.

Pre-trip Travel Information

The third point at which IVHS enters the traveler's decision-making process is in having information available before the trip commences, or pre-trip travel information. Such Advanced Traveler Information Systems offer the traveler the opportunity to base the time, mode, destination, and route of a trip on information about the status of the transport network at a particular point in time. The technologies providing these services include the end-user devices for access (PCs with modems, televisions, telephone, personal digital assistants, kiosks, etc.); wireless and wired communication networks; the software and databases for collection and delivery of information; and a variety of sensor technology by which information is collected.

What do we know about the use of pre-trip information in changing travel behavior? A Southern California survey' revealed **that** 36.5% of commuters seek traffic information before leaving home, but of these less than **20**% change their route. In New Jersey, 72% of commuters would prefer to use a potential incident information service to change route, 20% to change mode, and 8% to change time of departure." In Washington State, 75% of surveyed commuters showed a willingness to use information to make changes in their commute." However, even among those willing to make a change, few would change modes.

Results from the single actual field test of a traveler information service, the fifteen-month test of Boston's SmarTraveler service," paint a more conservative picture for pre-trip information services than the other studies might suggest. Overall usage was low relative to the total Boston market that had access to the service. Noticeable peaks in usage did occur during severe weather conditions, when traffic conditions were at their worst. Travelers who used the service said they made changes to their trip in 29% of the cases, with change in departure time and using a different route the most frequent types of changes. Canceling a trip altogether and switching modes were much less common, 2.2% and 1.0% respectively.

To have significant beneficial environmental results, many travelers will need to make use of pre-trip information. Surveys indicate that travelers are interested in taking advantage of such information and making changes in trip decisions. As yet, modal shifts are unlikely to occur based on information services alone. Moreover, to achieve significant penetration pre-trip information services may need to be provided at no charge. In New Jersey and in Boston, interest in the service dropped dramatically as prices were introduced.

En Route Travel Information

The final stage of trip decision-making where IVHS comes into play is en route. En route travel information allows a traveler to alter a trip once it has commenced. Technologies similar to pretrip travel information services are used, with the exception that communications tend to be wireless. Also, in-vehicle navigation units and routing systems track a traveler's progress through the transportation network and provide real-time route guidance.

What do we know about the potential usage of such systems? Results from a couple studies are available. Among cellular network subscribers in Boston, the SmartTraveler service cited earlier" was used in much higher proportion than among land-line subscribers, suggesting a greater perceived value for en-route usage. In the TravTek trial in Orlando, Florida. drivers experienced a perceived and actual travel time savings with the route guidance system. ^{13. 14} Moreover, drivers thought the system helped them drive more safely.

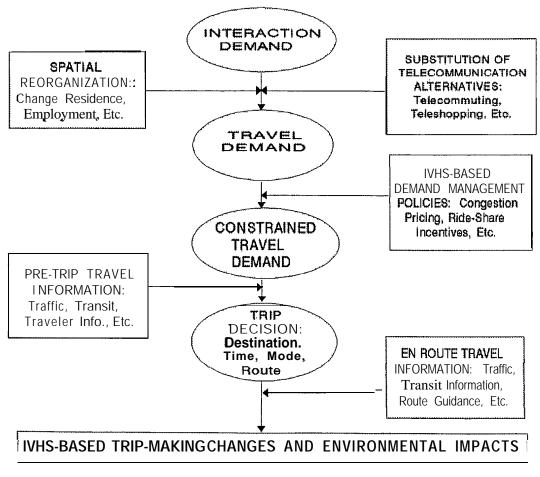
These positive findings suggest that en route information will be well received in the market, assuming that price and other factors are satisfactory to travelers. As the experience to date has been with in-vehicle devices, the potential for modes other than a traveler's own vehicle is not known. Besides the benefits of reduced time and stress for the traveler, potential environmental benefits may be achieved by avoiding traffic tie-ups and more efficient routing.

OBSERVATIONS ON THE RESEARCH AND CONCLUSIONS

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Based on Shladover. 1993 121

Figure 1. IVHS in the Travel Decision-Making Process (Based on Shladover, 1993²)

MR. CROSBY: Thank you very much, Carol. One of the studies that Carol referred to and. also, she discusses at more length in her paper was our smart traveler project which is a field operational test in Boston. It is a fully deployed area-wide audio technology service where you can dial into our data base, and punch in your route number and get information or punch in your transit quarter and get up-to-the-minute information with an intent to try to be as aggressively multimodal and alternative routish and so forth as possible.

There were some interesting pieces from Carol's presentation related to the fact that we just had an independent evaluation done by an outside contractor hired by the Massachusetts Highway Department. They called 2000 users of the service and found that 49 percent had in some fashion or other had their travel behavior directly and significantly impacted by their call into this ATIS system. Twenty-nine percent actually changed the time or route or mode of their travel, the mantra that we all chant. Another 20 percent used the data to pick between two alternate routes that they knew about.

On the other hand, usage on an overall absolute basis is low, but if you can convert that kind of impact of an ATIS system into widespread usage across the target audience you are talking about very profound impacts. One percent of the users did change mode. Two percent of the users did not take the trip at all. If there was widespread usage that 3 percent would be a big impact. So, there is a mixed message which Carol's paper documents. On the one hand this behavior modification, the "will the user come?", the answer is maybe if we work very hard at it, but the good news is that it does appear that people are rational, and when they can learn to access quality information they will, indeed, change their behaviors. It is a significant step, I think.

Our fourth and final speaker is Dr. Lisa Saunders who is an assistant professor at the University of Massachusetts at the Amherst campus where she researches and teaches labor and transportation economics. The particular topics that she teaches are interesting, introductory and intermediate micro-economics, labor in the American economy, political economy of women and a graduate seminar in labor economics. She is presently on leave from U Mass, Amherst and is a postdoctoral fellow at the Humphrey Institute at the University of Minnesota where she will be for another month or so.

IVHS: POTENTIAL IMPACT ON DISADVANTAGED COMMUNITIES

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INTRODUCTION

This paper explores the impact of transportation technologies on the social and economic well-being of central city residents and disadvantaged populations. Though members of poor communities have little political power or input into the decision-making process, transportation policy affects them in many ways. We demonstrate that the impacts of new projects on the earnings, wealth, health, education, and cultural amenities of disadvantaged residents can be measured, and that transportation project development, finance, and operations can be undertaken in a distribution-conscious way.

To estimate one fairly broad impact of IVHS transport policy, we use census data for the three case study Metropolitan Statistical Areas (MSAs): Houston, Minneapolis-St. Paul, and Portland, OR. To assess potential impacts on disadvantaged workers of IVHS projects we examine racial and income differences in travel time to work. Controlling for demographic characteristics, we estimate the relationship between commute time and income; and use measures of potential time savings from IVHS projects to simulate their impact on incomes and inequality. IVHS technologies have the potential to increase and improve access by central city residents to employment and to mitigate race and income disparity in travel time and perhaps earnings. Successful implementation of these technologies will result in declines in employment and earnings inequality.

THE CASE STUDY CITIES

Houston is the largest of the three case study cities. Table 1 shows that there were over 3 million residents in the Houston MSA in 1990. There were 2.5 million in Minneapolis-St Paul and 1.2 million residents in Portland. The populations of Houston and Minneapolis-St Paul (MSP) increased 13.6 and 16.6 percent respectively between 1980 and 1990. But the population of Portland decreased slightly (0.22 percent). In all three cities the non-white population grew faster than the white population. To point out the fastest growing group: the Asian population of Houston grew 146.8 percent. In MSP it grew 231.2 percent and in Portland the Asian population grew 93.4 percent.

Table 2 shows that the mean travel time for commuting to work (commuting by all means of transportation) was higher in Houston than in Minneapolis-St Paul and Portland in 1980 and 1990. This is as might be expected, given the larger size and decentralized nature of the Houston MSA. Travel time to work differed by racial ethnic group in each of the cities.

Travel time to work increased for whites in all three cities and decreased for non-whites in Houston and Minneapolis-St Paul. In Portland, mean travel time differed very little between whites and non-whites, but it differed among individual ethnic groups. In fact, the differences by race in mean travel time are obscured by the comparison of whites to all non-whites in all three cities. Houston provides the best example of this phenomena. Non-whites' mean travel time was longer than that of whites both years, but the difference between these two "groups" narrowed between 1980 and 1990. This narrowing was primarily due to the decrease in the mean travel time of blacks, who were the largest non-white group. Their mean travel time fell 6.66 percent. But all other non-whites had their travel time increase during the period, including the second largest group, Hispanics.

McLafferty and Preston (1991) use 1980 census data to examine gender and race differences in commute time throughout the New York City MSA. They find that black and hispanics have longer commute times, and that gender differences in commute times among whites are mostly explained by differences in industry and

occupation. Differences between minorities and (white) women's commute times in 3 of 6 service industries they studied are also explained. In the other industries a significant difference remained, perhaps because employers located some (low-wage) jobs "near a white female labor force." Economic factors did not explain minority workers' longer commute times. The authors suggest that "racial discrimination in job and housing markets" have made them "transit captives."

The notion of a transit captive comes from the earlier work of Rutherford and Wekerle (1988), who examined "the impact of residential and workplace location and mode of transportation to work on the incomes of female and male workers." They used household survey data collected in Toronto, Canada to evaluate journey to work and income characteristics of transit riders and automobile users. As did McLafferty and Preston, they found women worked closer to home. "When travel costs are compared with potential income gains, (they) find that women, and particularly women using transit, have less to gain than do men by traveling farther to work." For non-white workers it would be expected that they travel shorter times than whites because they receive lower pay-making a long commute less worthwhile.

Table 3 shows mean travel time by race and gender. In all three cities women's mean travel time to work is lower than it is for men. This was true in both years for whites and non-whites. Previous research has shown that women tend to travel for a shorter time and distance to work than do men? McLafferty and Preston(199 1) found that although black and hispanic men and women did commute a longer time than whites, there was very little difference between black men and women and hispanic men and women in mean travel time. Table 3 supports this finding for white and non-white men and women in Houston and Minneapolis-St Paul, but not for Portland. In Portland both white and non-white commuters differ by gender in travel time to work.

Table 4 and Figure 1 show that in all three cities non-whites are twice as likely to use public transportation This fact is likely to account for some of the racial difference in mean travel time. Figure 4 demonstrates how public transit use increased in Houston for both whites and nonwhites as it declined for both groups in the other two cities. The relationship of means of transportation and income disparity is multi-facetted in the literature. There are differences in financing the development of transportation projects, differences in pricing of the services, and differences in the access, quality, and speed of the service that need to be measured. In some cities the tax burden for financing transportation falls disproportionately on lower-income residents. Fares formasstransit (relative to costs) are often higher for users from the central city (Hodge 1986). Access and quality have been found to differ by income group, as well, though commuters are guaranteed equitable quality of mass transit (by UMTA): age of vehicles, load factors, access to services. The measures sanctioned by UMTA are problematic; and the notion of what constitutes equal access is complicated by family structure, age, and other factors. Brian Taylor's "Unjust Equity: An Examination of California's Transportation Development Act" provides an insightful discussion about how funds from the "largest nonfederal public transit funding program in the country" are allocated. He finds "a proliferation in California of new, well-funded, and expanding suburban transit operators that attract few riders, whereas older, heavily patronized central city transit operators are forced to cut service because of funding shortfalls." New transport technologies would probably need to be applied more equitably to address inequality in access to jobs and income. Thus we now turn to a discussion of travel time and income.

Figures 2 - 4 show travel time for whites and non-whites who had less than median income. Median income for nonwhites in Houston in 1990 was \$29,193. In MSP it was 33, 612; and it was 33,000 in Portland. Whites' median income was \$45,359 in Houston in 1990. It was 46,663 in MSP and 40,070 in Portland. In all three cities the majority of workers traveled to work in 45 minutes or less. The distribution of whites and non-whites traveling to work was fairly similar and changed in similar ways from 1980 to 1990. The majority of commuters with below median household income traveled to work in under 35 minutes. Any increase from 1980 to 1990 in the share of commuters traveling a longer time was dominated by commuters traveling over one hour. Among commuters traveling less than 35 minutes, those traveling 30-35 minutes seem to have cut their travel time slightly. (Non-whites seem more likely to have achieved this.)

Residences located in central cities tend to be located close to work, family and social institutions that serve their communities. Growth accommodated and fostered by expanded highway transportation in recent decades has fragmented residential areas and facilitated the development of large residential communities outside the cities.'

Suburban dwellers have gained ease of transportation to work, higher property values, and similar benefits from transportation innovations while central city residents experienced declining access to jobs, business, and public services. Below we model and estimate the effect of easing transportation to work on income inequality. We focus on mass transit and private vehicles because the majority of workers commute using these modes. All of the cities include other projects such as walking paths and bike routes in planned additions to their transportation infrastructures, but Census figures show that a very small share of total persons travelling to work walk or ride bicycles. In any case we would like to acknowledge the fact that policies developed for such projects can have disparate effects on neighborhoods and their residents.

THE MODEL

Residential location decisions and work decisions are intertwined in the long run. Persons may consider moving closer to work in order to reduce commute times or they may consider moving further away from the central business district in order to avail themselves of lower housing prices. Ultimately, there must be a trade-off between distance to work and housing prices. In the short-run, however, consumers are constrained in their housing choices and/or employment prospects. One reason for constraints on housing choices may be historic patterns of housing segregation of some groups near the inner-core and other groups in suburban areas. A reason for constraints on the location of employment prospects might be similarly related to historic patterns of location of certain businesses, like shopping malls and retail shops, near one group but far from another.

A reality for many cities, moreover, is that there is a mis-match between where firms are located and where people live. For example, many African Americans are concentrated in inner-city and older suburban cores. Newer and growing manufacturing firms often locate outside of the urban core. Minority workers may have to endure long commutes in order to avail themselves of these jobs. As another example, many white families have moved to new suburban developments, where housing prices are moderate. For some, commute times to professional jobs in the central business district may be substantial. Taking jobs closer to home often means taking a pay cut. In the shortrun at least, locational decisions can be thought of as fixed. The choice is one of how long to commute to get to a job. This choice problem arises in part because wages are equal across space for each group.

Thus, at least in the short run, the choice that the consumer faces is really a choice between commute times and work. Or alternatively, the choice is between commute times and consumption which is constrained by income from work. Given wherever a particular group member happens to live and the distance between the group member's residence and employment prospect, the consumer chooses between expenditures on consumption goods and on time allocated to commuting. Longer commutes mean less time for work in this simple framework. Thus, it means lower earnings and thus, lower consumption. The choice, then, becomes one of spending time getting to work or spending time working. But a constraint is that wages are higher the farther away you commute. This constraint arises from the fact that in the short-run consumers are assumed to be unable to move closer to the better jobs, Without further specification on the relationship between wages and location and the variations that might hold for different groups, there is an ambiguous relationship between travel time and earnings.

To see this, consider a very simple conventional time-consumption choice model. Let C be consumption, t is travel time, L is time spent in work, w is wages, and p the price of consumption goods. Assume that all income is spent on consumption. so that earnings plus initial income equal consumption. Also assume that time spent at work equals available time less commuting time. The problem of the consumer can be thought of as one of choosing the combination of consumption and commuting so as to maximize a utility function given by U, subject to an income constraint and a time constraint. That is:

$$\mathbf{Max} \ \mathbf{U} = \mathbf{U} (\mathbf{c}, \mathbf{t})$$

subject to:

$$p.C = w*L + \Upsilon$$

$$L = T-t$$

In general, the optimal allocation of time to travel, t^* , will decline for increases in w. To see this, consider the case of a Cobb-Douglas utility function:

$$U = C^{\alpha} t^{(1-\alpha)}$$

The solution to the constrained maximization problem becomes:

$$t * = (1 - \alpha) \left[\frac{Y/p}{w/p} + T \right]$$

t is easy to see, moreover, that t^* declines for increases in wages, but rises for increases in initial wealth, \tilde{Y} , and available time, T. In other words,

$$\begin{array}{c} at^* < 0, \ \frac{at^*}{\partial Y/p} > 0, \ \frac{\partial t^*}{\partial T} > 0 \end{array}$$

The last two derivatives suggest that the more wealthy and those with more time to spare are more likely to commute for longer periods than those with little wealth or little time to spare. Thus, for example, one would expect that mothers with young children -- and thus with little time to spare -- will have lower optimal allocations of time to commute than fathers. For evidence of this see Johnston-Anumonwo (1988). Part-time workers and those who do not own cars would also be expected to have lower optimal allocations of time to commuting.

Although other specifications of the utility function can reverse the finding of an inverse relationship between commutes and wages (for example a quadratic utility), the central point here is that under reasonable assumptions one can expect optimal commute times to decline as wages increase. But this would be true if we are willing to assume that wages themselves are unrelated to where people live and thus how long it will take for them to get to work. We must also need to assume that wages are unrelated to the initial wealth that might affect the form of transport available to the worker. That is, we must ultimately adopt the restrictive assumption that car ownership -- which will reduce travel times for given distances -- is independent of wealth if we want to assure that the simple inverse relationship between travel time and wages will hold. Clearly this assumption is too restrictive and generally will not conform to the experiences of most cities. Therefore, in the absence of such restrictions as the independence of earnings and wealth, the relationship between earnings and time traveled can no longer be signed unambiguously. The precise relationship, consequently, becomes a matter of empirical verification and is likely to vary from city to city and group to group.'

EMPIRICAL SPECIFICATIONS

The interest in the relationship between travel time and wages is to assess whether technological improvements in transportation that reduce travel time will also reduce racial earnings inequality. Using Census data we can estimate earnings equations which isolate the impacts of travel time from other factors such as industry and occupation.

To do this we must first invert the relationship isolated in the rational choice model sketched in the previous section. We noted that $t^*=f(w/p)$. We do not observe real wage rates, w/p, directly. What we observe is wage and salary incomes, conceptually equal to the product of the wage rate and hours worked, or $(w/p)^*L$. But $w/p=f^1$ (t) and L=T-t, suggesting that in any empirical specification of earnings and travel time, travel time must be considered endogenous.

To assess the monetary return to commuting, we can estimate the effect of travel time on wage and salary earnings:

$$\ln(w/p \cdot L) = \ln(earnings) = \sum_{i} \beta_{i} X_{i} + \gamma \ln(t^{*}) + \delta(L/T) + \mu$$

where t^* is measured by average commute time to work, L/T is percent full time, measured by usual hours worked times weeks worked divided by 50 weeks. To obtain estimates of the coefficients, β , γ , and δ , we use the method of two stage least squares. The interpretation of γ is the percent change in earnings as a result of a one percent change in minutes spent commuting. The return to commuting, or the percent change in earnings as a result of a one minute increase in travel time, is given by: $\partial \ln(\text{earnings})/\partial t^* = y/t^*$. To assess how differences in t^* across groups and across years affect earnings inequality, we note that relative earnings inequality changes between 1980 and 1990 can be measured by:

$$\ln(I) = \ln\left[\frac{y_{80}^B/y_{80}^W}{y_{90}^B/y_{90}^W}\right] = \ln(y_{80}^B) - \ln(y_{80}^W) - \ln(y_{90}^B) + \ln(y_{90}^W)$$

where y denotes wage and salary earnings and superscripts B and W denote nonwhites and whites, and subscripts 80 and 90 denote years 1980 and 1990. When In(I) declines, inequality is diminishing. A uniform one minute reduction in travel time t* will decrease racial earnings inequality as:

$$\partial \ln(I)/\partial t = \gamma_{80}^{B}/t_{80}^{\#} - \gamma_{80}^{W}/t_{80}^{\#} - \gamma_{90}^{B}/t_{90}^{\#} + \gamma_{90}^{W}/t_{90}^{\#} > 0.$$

Thus, our exercise is designed to estimate y's for whites and nonwhites for the years 1980 and 1990 in order to determine the potential impacts on earnings inequality of technologies that reduce travel time.

RESULTS

The factors, other than commute time, that are included in the earnings equation are: percent full-time employment, central city residence, age, education, production/operative occupations, manufacturing industry, retail industry, and a dummy variable for unmarried females with young children. The log-earnings equation was estimated for Houston, Minneapolis/St. Paul, and Portland for 1980 and 1990 using U.S. Census Public Use Micro Samples. The results are shown on Table 5. Positive and highly significant coefficients are obtained for all three cities for both censuses on the percent full-time variables. Central city residence lowers nonwhite earnings in Portland, and white earnings in Minneapolis/St. Paul. It raises white earnings in Houston in 1990, and leaves a statistically insignificant impact on the other years and groups. Thus, the impacts of central city residence -- controlling for other facts -- differ widely from city to city.

Age and education generally have positive impacts on earnings, as most human-capital models of earnings predict, although the coefficients for nonwhites in Minneapolis/St. Paul are not all statistically significant. The industry and occupation variables are not uniformly significant, although in every instance retail employment lowers wage and salary income. The last factor, other than commute time, is a dummy variable for unmarried women with young children. This factor consistently lowers earnings for nonwhites but not in all instances for whites. The coefficients, however, are not uniformly significant at the 5 percent level.

The estimated coefficients of commute time vary by year, group and city. In Houston, a one percent increase in commute time increases earnings for whites in 1980 and 1990. The estimated elasticities increased from 1980 to 1990 for whites, meaning that the payoff for longer commutes increased. In 1980 the elasticity was .14. By 1990 it was .46. That is, the payoff to commuting more than tripled for whites living in Houston. Although the mean commute time for whites did not change much in the intervening years (from 25.97 minutes to 25.98 minutes) the returns to commuting increased dramatically.

In contrast, the effect of commuting times on nonwhite earnings was negligible and statistically insignificant. Even though mean commute times diminished for nonwhites in Houston from 28.44 minutes in 1980 to 27.24 minutes in 1990, there was little impact of these reductions on earnings.

The effects of commute time on earnings in Minneapolis/St. Paul are statistically insignificant, except for whites in 1980. In 1990, however, the coefficients -- although statistically insignificant -- were positive for both whites and nonwhites. They were also larger for nonwhites than for whites. Ignoring the fact for a moment that these elasticities are statistically insignificant, one observes that the nonwhite elasticities exceed the white elasticities and that the gap widened between 1980 and 1990. That is, the payoff to commuting increased for nonwhites. Still, nonwhite workers in Minneapolis spent less time commuting in 1990 than they did in 1980, with a mean travel time that fell from 22.42 minutes to 19.16 minutes as compared to a slight increase in travel time among whites (from 19.70 to 20.92 minutes). Thus, although there exists a payoff to longer commutes for nonwhites -- presumably to good jobs in the suburbs -- there may be barriers to nonwhites who wish to secure these good jobs.

The situation in Portland is quite different from the other two cities. Note that there is little difference in the average commute time between whites and nonwhites. In 1980 the averages were 2 1.23 and 2 1.20 for whites and nonwhites; in 1990 they were 22.0 1 and 22.15. Moreover, the effects of commute times on earnings for whites and nonwhites were negligible for both years. A one percent increase in travel time changed earnings by a statistically insignificant amount ranging from six one-hundredths of a percent to one tenth of a percent.

In summary, then, the effects of commuting times on earnings vary from city to city and group to group. And yet, there appears to be a consistent impact of uniform reductions in travel time on earnings inequality. A one percent across the board reduction in travel time would have reduced the growth of nonwhite-white earnings inequality for each city. Or stated differently, a one percent increase in travel time contributes to the growth in earnings inequality. We have computed the percentage change in I due to a one percent change in t*, given by $\partial \ln(I)/\partial \ln(t^*)$. The results for Houston, Minneapolis/St. Paul and Portland are: .33 percent, .05 percent, and .17 percent. See figure 5. In other words. a one percent reduction in travel time to work lowers the ratio of earnings in 1980 to that in 1990 by five one hundredths to one third of one percent. That is, it reduces the racial earnings gap. Unfortunately, it does not reduce the gap by much. The computed elasticities are all less than one, meaning that there is but a minor responsiveness of changing racial earnings inequality to changes in travel time.

Earnings inequality widened in all three cities from 1980 to 1990. Although earnings increased for both whites and nonwhites in every instance, the percentage increase was greater for whites than for nonwhites. As a result, the ratio of nonwhite/white earnings in 1980 to that in 1990 rose. The increase was 8 percent in Houston, 7.5 percent in Minneapolis/St. Paul and 27.5 percent in Portland. Thus, the widening and conspicuous gap in racial earnings can be reduced somewhat by improved transit or technological innovations that reduce travel times, but not by much.

Stated differently, widening earnings gaps are likely to be the consequence of increasing commutes that result in further isolation of inner-city nonwhites from good paying jobs in the suburbs. Reduction in commuting times -- if uniform between whites and nonwhites -- will not have an adverse impact on earnings inequality, as a result. Other public policies will have to be devised to reduce racial earnings inequality. Transportation policies alone may not be particularly effective. Nevertheless, neither will transportation policies that restrict themselves to equality in time-reductions necessarily contribute to the further widening of the earnings gap. Indeed, as our estimates show, equal reductions in travel time will lessen earnings inequality. While the lessening will not be great, and the effects will be quite inelastic, the impacts will be positive.

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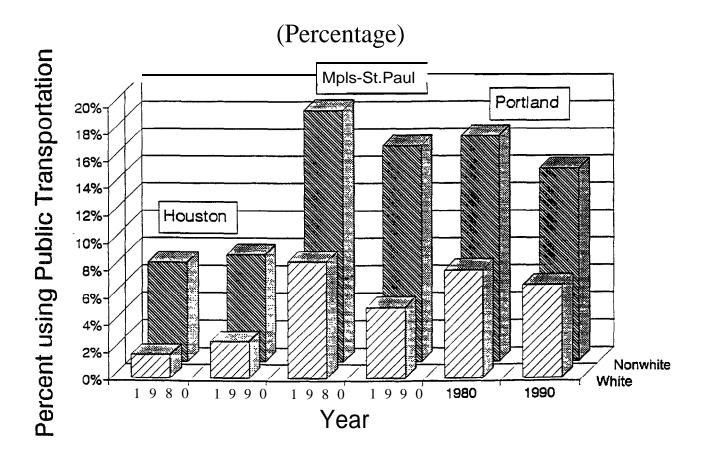
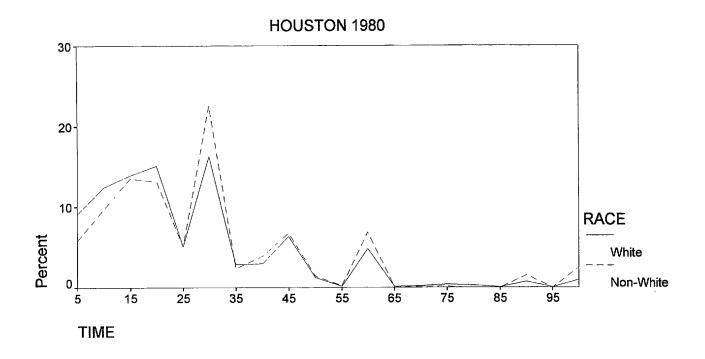


Figure 1. Public Transportation By Race



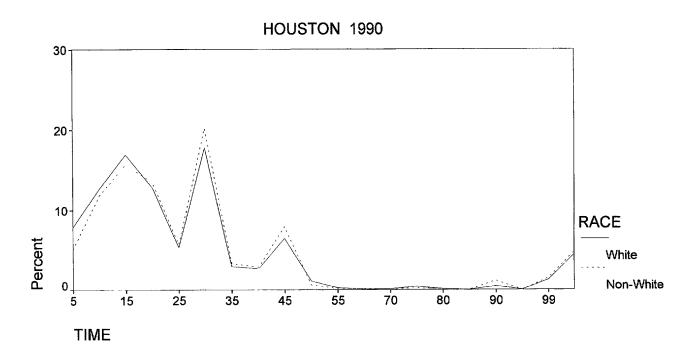
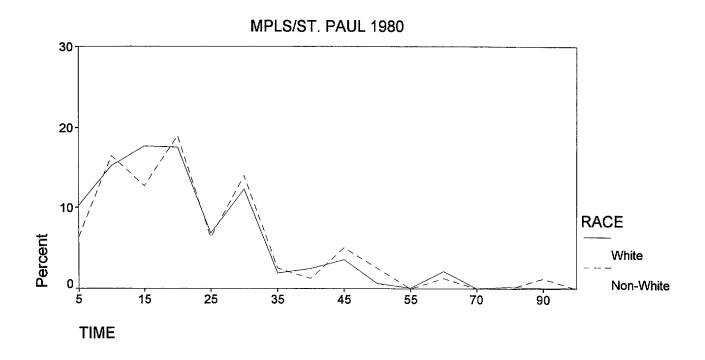


Figure 2. Travel Time By Race Percentage of Persons Below Median Income



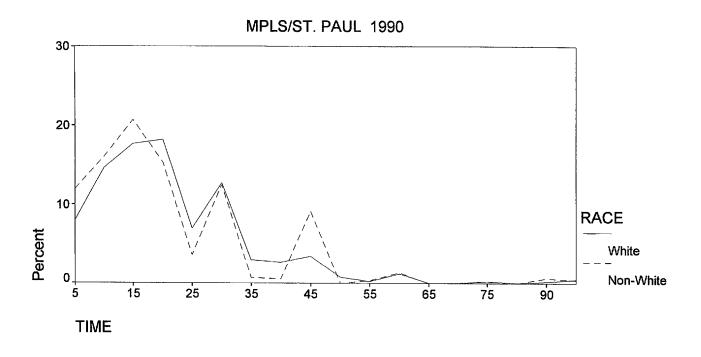
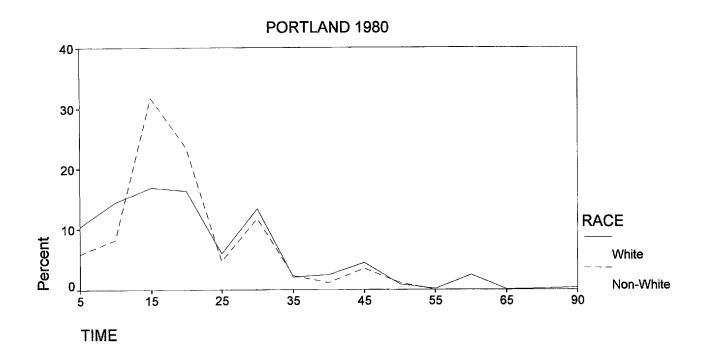


Figure 3. Travel Time By Race Percentage of Persons Below Median Income



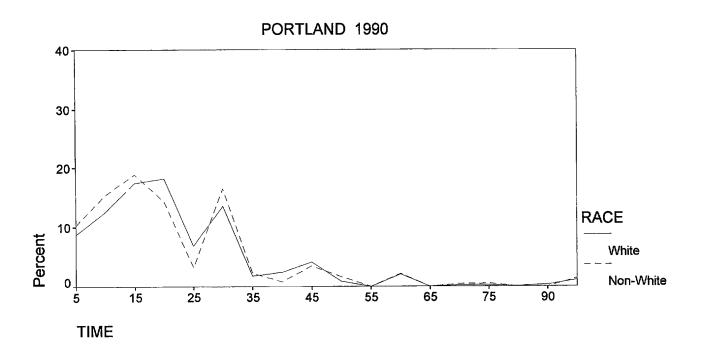


Figure 4. Travel Time By Race Percentage of Persons Below Median Income

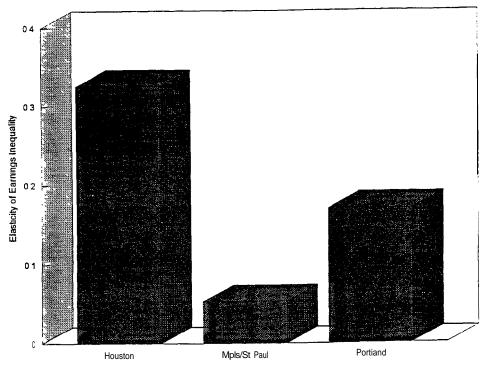


Figure 5. Elasticity of Earnings Inequality with Respect to Travel Time

ENDNOTES

- 1. Hedge (1986) also noted that the "choice" to take public transportation is not a choice for the carless.
- 2. See Rutherford and Wekerle (1988), Ibipo Johnston-Anumonwo (1988) and McLafferty and Preston(1991).
 - 3. Houston and Minneapolis-St Paul are better characterized by this statement than is Portland.
- 4. Gatzlaff and Smith (1993) provide an informed discussion of the effect on property values of monorail station location in Miami. They find residential property values were only "weakly impacted" but adverse impacts on property values were most likely to occur in lower income residential areas.
 - 5. For example, consider the relationship between earnings and wealth:

$$w/p = \sqrt{Y/p}$$

Since for the Cobb-Douglas utility function:

$$t * = (1 - \alpha) \left[\frac{\overline{Y/p}}{w/p} + \overline{I} \right]$$

it follows, then, that instead of reducing optimal commute time, increases in wages increases it, with this addition to the model.

6. These are instantaneous rates of change computed from the formula: $\ln(y_{80})^b \cdot \ln(y_{90})^w \cdot \ln(y_{90})^b + \ln(y_{90})^w \cdot

QUESTION AND ANSWER SESSION

MR. CROSBY: I think I have probably been to 50 IVHS conferences of one sort or another, and never has there been, that I can remember, any focus on or attention given to the issue of the impact of IVHS on disadvantaged communities, which incidentally was a mistake that was made in the early days of building highways when we, also, had an unerring instinct for building them in disadvantaged communities and not taking into consideration the impacts. We would be well advised not to repeat the sins of our fathers.

We have a few extra minutes, if there is interest on the floor. We can take 10 or 15 minutes for questions if people would like to ask them.

MS. HATHAWAY: This is a question for Mr. Ostria. I am struck by the conclusion that you seem to be drawing that if there is not the same number of vehicles on equally congested roads in the long run that there won't be an increase in emissions. That seems a problematic conclusion to start with.

MR. OSTRIA: I think your comment is well taken. I think the issue to begin with is very complicated and is not necessarily straightforward, and I did not mean to imply that increased travel will not occur. You reduce the price of something, and people are going to consume more of it, that is the basic result of microeconomic phenomena. If you look at it from the point of view of the microeconomic principles and the framework that economists use to evaluate those types of things, the whole area under what is called the demand curve is latent demand.

However, it is important to keep in mind that by reducing the price of travel, you are, also, going to have direct benefits to the users in terms of increases in consumer surplus as well. So, while I agree with you, in general I think you are right, it is difficult at this stage to say that some IVHS systems are going to improve traffic flow, increase NOX emissions because you are increasing travel speed and decrease possibly carbon monoxide through improvements in travel flow. It is, also, important to keep in mind that the way to manage transportation is just not to ignore the problem of congestion. I do not hold the view that good policy is to do nothing and drive the cost of driving so high that people aren't going to, you know, that congestion is just going to be driven to a point where you are really squeezing out all of the benefits of mobility for people.

I think, also, if you keep in mind the concept of mobile source emissions as well, for example, we are really not looking at things in isolation to being with. Technology is very important, and what you want to do, as I see it is internalize the externalities of motor vehicle travel, and as people in the environmental community have argued and have mentioned over and over again, which I am in agreement with, is that one way to do that is increase the price of travel. However, that is a very difficult political sell.

So, the other options might be that IVHS can really help to reduce emissions by acting as enabling technologies for other things like supplementing inspection maintenance programs through remote sensing and on-board diagnostic systems that basically will be able to monitor emission levels in vehicles on a real-time basis, These types of things are very important because they directly internalize the externalities associated with emissions.

So, I did not mean to imply that induced demand is not a problem. It is just an economic reality, and associated increases in travel obviously are going to increase emissions because we are going to have vehicles. It is just that the studies that we looked at showed that the demographic and economic factors that changed the quantity of travel are a lot more significant than marginal increases in induced travel as a result of reductions in user costs.

MR. ROGERS: I have a quick question. My name is Bill Rogers. I work for the Center for Neighborhood Technology in Chicago. Ms. Zimmerman, in your review of preliminary research results you said that pre-trip information systems had not been shown to be effective in inducing a change in mode selected. I wanted to ask if you knew if that was a unimodal information system that just presented highway information or if it presented alternative transit information, in other words, saying that I-10 is congested, but there is a train going in that direction in 30 minutes?

MS. ZIMMERMAN: One of the studies was in Boston, and I believe there is some attempt there to include some transit information, but it probably is not as extensive as what you are referring to. Steve, do you know'?

MR. CROSBY: I don't know about the other ones, but in the case of the Smart Traveler field operational test in Boston, it is intentionally and as aggressively as possible multimodal. Clearly the lion's share of the interest is about traffic, but there is a conscious attempt to refer people to alternate modes where it is viable and you know, when it is Friday afternoon just to remind people of the water shuttle to the airport and so forth. Further, there was a 1 percent change in mode which is a lot more than a no percent change in mode and given the increments that we are talking about not trivial, but it is, also, a learning curve to figure out how you can collect and package and disseminate data that people will listen to, follow and gain confidence in. Then it takes time for people to get in the habit of doing it. So, my reaction to that was if we had any impact on mode at all, that is pretty amazing, and maybe there is some marginal utility to continue to upgrade the data from multimodes to help move people to different modes.

MS. ZIMMERMAN: I would also point out that these studies need to be looked at more closely on whether an individual has a realistic modal choice to go to. As you know, in many places transit is not a real alternative for some, perhaps many, people.

MR. GREENBERG: Allen Greenberg from the League of American Bicyclists. I had a question for Dr. Saunders, and if it is in the paper, I apologize. I am wondering if the travel time reductions you found for minority communities might be a result of the outgrowth of suburban jobs being inaccessible to people without an automobile and, if that is the case, which minority communities are in that situation and I wonder whether some of the IVHS technologies that reduce travel time for automobiles might actually make the situation worse by encouraging those kinds of business location decisions that make it even more difficult for people without cars to get there?

MS. SAUNDERS: I think that is a good question. I would like to respond with an example. It was the case that returns to travel time increased for non-whites in Minneapolis-St.Paul from 1980 to 1990. Yet, mean travel time for those groups declined. That these groups did not appear to change their commuting behavior implies that there may be either discrimination in hiring: the jobs are simply not available to them; or a lack of transportation.

It is difficult using the same census data to say anything about firm behavior without firm-level data. It is quite likely that transport options (as you suggest, such as reverse commuting) were and are not available to people in central city communities. In Minneapolis, I know, that some employers have begun to provide transportation for inner city workers of color, but I believe this is unusual.

MR. KESSLER: Jon Kessler from EPA. I will save my response on the relative progress since 1970, of air quality and transportation modeling, but I had one question for Sergio and I think it is a duality in this sort of analysis that confuses me, and I have to admit as a micro-economist I appreciate the use of graphs and tables. They make all this much easier for me to understand, but the thing I do not understand is that what you initially tell us in saying that the response of commuters to declining travel costs is low is that the price, the elasticity of demand with respect to price for travel is relatively low, that is people don't respond to it. At the same time, we hear quite frequently discussions of IVHS that this is likely to have huge benefits. If I had another good like Oreo cookies, and I made some investment, for example, a government investment that reduced its cost, but I found that the only result of that or as a result of that not very many more people were buying Oreo cookies I would interpret what I had done as basically having the effect of sort of a transfer of cost from consumers to producers, and I would assume that the welfare benefits of that would have been relatively low.

So, the thing that I get out of your study is either that we are likely to see induced demand because people really care about travel costs declining or what IVHS really amounts to is just a shift in costs and the actual welfare gains are likely to be kind of low. That was more of a statement than a question, but what is your reaction?

MR. OSTRIA: First of all, to your comment about elasticity, of course, at this stage I think we need to go to the next level. We need to start quantifying these things and without implementing IVHS it is very difficult to

do that. So, comparing studies that look at capacity expansion projects and making the jump to IVHS is a leap in faith to begin with, but we don't have the tools to look at what elasticities look like, but my feeling would be that it is highly dependent on the type of trip.

Now, in the paper that we put together, I don't recall making the comment that necessarily everything would be inelastic. However, in terms of commuter trips that could very well be the case. With respect to the impact of IVHS under a scenario of an inelastic demand, what you are suggesting is that you would increase the marginal cost of driving to a point where the supply curve is shifting downward or decrease the marginal costs of driving to a point where the supply curve is shifting outward, but it is not increasing the equilibrium, quantity level of travel. Nevertheless, you do move along that demand curve and you are increasing the equilibrium level of travel. The point of the paper is that to address the problem of what people have called induced demand, first it is important to understand what it is because at the same time you have income and demographic factors that are shifting the demand curve out and those effects in many cases are going to be much larger, and one important thing is that it is very difficult when things happen in such a dynamic context to assess the welfare gains because of the welfare repercussions of induced travel, for example, because things are happening together and differentiating between the traffic growth that occurs as a result of decreases in prices versus that which occurs as a result of secular growth is very difficult, and specifically because most of these capacity expansion projects and highway investment projects are taking place where regions are growing quickly.

MR. CROSBY: This is a tough question to cut off because this is really at the heart of the matter. I hope that in the breakout sessions there will be room to examine this issue more because I think that trying to come to some kind of a common sense of the parameters of this discussion has a lot to do with whether or not there is going to be a working alliance among the parts of the IVHS community and the environmental community. However, as our host said, we can only get our last two questions in if questions and answers are succinct.

MR. ROUDEBUSH: I was very intrigued by one of the comments that Sergio made which was based upon his microeconomic planning-based findings. It reminded me of what my boss told me when I was learning about regional planning in the South of France. He said, "Peter, that is a great plan. Now, we have to wait 20 years to see whether it is a good one." I think the lessons that Lisa is telling us about are that we have to recognize that fact, and that we have to learn from our past history how we will change the planning 20 years from now.

MR. CROSBY: I agree. I was, as I said, struck by Lisa's presentation and findings, my history and in what was called the anti-highway movement in the mid-seventies. There are some other people in this room who were part of that as well. and it is an interesting to be reminded that there are a number of these issues about societal impacts and broadest environmental impacts that we have made mistakes on before in utter good faith and good plans, great plans, as Peter says, but we missed some bi,, big issues, and not missing them this time is what this is all about.

MS. LOWE: I will try to make my question quick. It is either for Sergio or Sal, and I am not sure which, but I would just like to say that I really appreciate the good, hard effort that is going into figuring out if IVHS will, in fact, induce demand, but at some point I start to ask myself if we are not beginning to split hairs because of the fact that nearly every piece of IVHS literature that I have read talking about the potential of IVHS to solve our problems in transportation starts out with the projection of a threefold increase in traffic, in VMT by year X and then proceeds from that point to demonstrate how IVHS will sort of help get us there, and fulfill that prophecy. I am wondering how, just how smart that really is and in fact, what is the difference between an increase in demand that is induced by IVHS versus an increase in demand that is merely facilitated by IVHS which is what we are planning to do. As you are all beginning to suspect this is more of a comment than a question but I do think it is apt, given that this session is on the application of the technologies for the environment, and wouldn't it be ultimately smarter in the big picture of things to really focus our efforts on transportation demand management and not have that as a separate user service but have it be an over-arching theme in how we apply these intelligent technologies and make it better than the status quo and the trends that are already in motion in the transportation system that is just of average intelligence?

Day One of the Conference continued with Breakout Sessions immediately following. A summary of the afternoon breakout sessions is found at the start of Day Two.

Day 2 June 7, 1994

National Conference on Intelligent Transportation Systems and the Environment

Conference Proceedings

The Renaissance Conference Center, Metro Washington DC

SUMMARY OF BREAKOUT GROUP DISCUSSIONS

Moderator: Phil Shucet Michael Baker, Jr. Inc.

INTRODUCTION

MR. SHUCET: I am going to do introduce the people that will summarize where things were when their breakout sessions ended yesterday. In the interest of time, we are not going to debate the issues now. The purpose of the wrap-up is to give everyone an idea of the direction each breakout session is headed so everyone can complete their work this afternoon.

We will take them in order with Group A, New Strategies and Technologies, Steve Burrington's wrap-up.

GROUP A: NEW STRATEGIES AND TECHNOLOGIES Spokesperson: Steve Burrington

MR. BURRINGTON: I have boiled down a long discussion into four major emerging issues. We covered a lot of ground so I cannot bring everything within the sweep of these four points or issues.

The first one issue was a surprise to me. It was: should national performance standards be set for ITS up front? We agreed that the states and localities should ultimately decide which ITS tools to employ. The question that follows is: whether all the tools in the tool box available to the states and localities should meet certain environmental standards or goals? Should, for example, all ITS technologies make transportation more energy efficient or should they minimize total environmental and economic costs to the public?

The second issue that emerged overlaps with the first. It is: Should consistency with ISTEA be a goal for ITS or a framework for ITS development? This two part issue begins with the question: Should ISTEA, in its planning regulations, call for a more energy efficient, less polluting, multimodal transportation system? It is fair to say those points are the hallmarks of ISTEA and of the transportation system that it calls for us to develop or redevelop. The second part of that is: Should energy efficiency, pollution reduction and multimodalism be the hallmarks of the ITS systems we develop?

The second part of this that ISTEA requires transportation planning to take account of its social, economic and environmental context and rejects transportation planning in isolation. It also rejects looking at the transportation system without reference to its broader context. The question is: Should ITS be developed with attention to the context of the transportation system and in particular should ITS be developed with attention to the 15 or 20 planning factors that are listed in ISTEA? As the gentleman from one DOT put it, should ITS have to account for all that for which the transportation system obviously is not wholly responsible?

A third issue that was discussed briefly and occurred throughout our session is: Should ITS technologies include demand management capability? The idea was that they at least have a demand management capability or options built into them. They all should have multimodal or intermodal capability. In other words, should we avoid wherever possible developing unimodal technologies or technologies that do not reflect or relate to or appreciate other modes?

Fourth and finally, an issue emerged toward the end of our session as to the environmental factors that affect ITS should be addressed. In particular, the environment has been inappropriately equated with or limited to air quality, when it should embrace a broader range of environmental issues. We did not get a chance to list what those might be or to discuss the pros and cons of that, but that was another major issue that emerged from the session.

MR. SHUCET: I should have mentioned that last night the moderators met for dinner and a work session molding what was reported out of each session into statements that would provide clear directions for today. So, if those of you who were in Steve and Mel Cheslow's session did not recognize all of those issues, it may be because last night we reformulated those remarks.

Session B was Energy and Environmental Implications and Mark Miller is going to summarize that for us.

GROUP B: Energy and Environmental Implications Spokesperson: Mark Miller

MR. MILLER: For each of our issues we have a headline that summarizes it. The first in the form of a question, How to deal with uncertainty? There is a need for improved quantitative models regarding the benefits and costs associated with ITS and issues such as induced demand, incident management, and others.

The second one is environmental triage on user services or the "no regrets" policy. What that means is there is a need to improve the working relationship between the transport and environmental professions such that a consensus based process will permit technologies either limited negative environmental impacts or clear benefits to be deployed on a faster track.

Number three was institutional issues regarding environmental stakeholders. There is a need to outreach to the public but not only the public, to other groups, professional transportation related disciplines such as public transit and planning to disseminate the ITS vision and its benefits.

Number four was environmental vision versus ITS America vision or mission statement. A need to possibly revisit the ITS mission to reduce or eliminate inconsistencies between the current mission statement and the environmental community's goals and objectives.

Number five is the question: "What are the full costs? There is a need to clearly define the externalities of travel and, in particular SOV travel, to further the debate on issues such as congestion pricing.

Number six -- this is one issue without a headline -- is the need to develop tools to derive disaggregated benefits and costs in the environmental area. Distributed over the users and non-users to allow more informed public policy decision making in issues of equity and fair distribution of costs and benefits.

Number seven, the definition problem, and this overlaps with Group A, the need to clearly define what environmental concerns are. "Is it just air quality or not? To what extent do we require consensus to move forward?

MR. SHUCET: The third group focused on Institutional Issues and co-moderators Chris Cluett and Peggy Tadej are going to summarize.

GROUP C: INSTITUTIONAL ISSUES Spokespersons: Chris Cluett and Peggy Tadej

MR. CLUETT: We started to tackle defining what we mean by institutions, institutional analysis, or institutional issues. We struggled, but settled on the importance of institutional change and strategies for bringing that about.

We looked at key institutions and asked how they ought to change to achieve environmental goals as well as the transportation objectives of the program. We asked if change requires a crisis circumstance to occur. Members provided examples of change under trying conditions, We discussed other circumstances that might be conducive to institutional change. One identified was leadership that gets out in front of the issues to move a program forward effectively.

We also noted that the circumstance we find ourselves in now seems conducive to dealing with institutional issues. In other words, an opportunity at this point may be to involve a full range of disciplines and perspectives in tackling this problem.

The mission was important to keep in front of us. That mission should include transportation and the environment in setting goals and action strategies and it is important to revisit those frequently. The notion that once you set yourself on a particular institutional course, we cannot sit back and watch things unfold. We must deal with changing circumstances all the time.

The educational process that seeks a common language for the environmental and transportation communities is another important vehicle for institutional change. We need attention to active planning. Public involvement is important in the institutional arena in order to bring about the change we seek.

Another approach to bringing about institutional change is effective marketing strategies that create change through demand creation. We need strategies for achieving what I might call institutional culture change. By that we mean the norms, the understandings, the expectations of those who are members of the various institutions. We need to know their mind set, how they view the world, what is important to them. Can we get different participants and stakeholders from different institutional settings to communicate together effectively. We also acknowledged geographic variations in ITS institutions are likely to change.

I wanted to put this last one up. This is where we are going in our afternoon breakout session. We think there are three points to cover. The first is what are the institutional changes we can recommend? Who do we think has the responsibility or the authority to carry out those changes? What is a reasonable or plausible time frame within which these changes might occur?

MR. SHUCET: The last group focused on Societal Implications and will have co-moderators Gary DeCramer and Ellen Williams give the wrap-up.

GROUP D: SOCIETAL IMPLICATIONS Spokespersons: Gary DeCramer and Ellen Williams

MR. DECRAMER: We had a group that engaged in a diverse number of issues under societal issues, but we focused principally on four.

The first one isse we focused on was the whole issue of public participation. The fact that the users, the consumers of this technology, have not been fully involved in the process of planning and implementation of this technology. Under that, we had a subcategory that, though industry and government are present, they listen to the public but pay little attention. The evidence of that is the lack of response.

Another element of the participation process is the need for consensus building exercises. A point made by Brian Ketcham was the need for money to be spent for public participation. With regard to participation, while planning is there people often do not know what ITS is.

The second issue was that land use has been ignored as an issue. What needs to happen is we need to know what the local economic impact of urban sprawl. What is that economic impact of sprawl, what does it do to communities?

The third issue is to build in societal benefits and costs, including externalities. For that, we need the data and tools for building complex models.

Lastly, there was a range of equity issues, including attention to the needs of disenfranchised communities. Gor that we need some better tools for analysis, similar to a paper presented yesterday I believe by Lisa Saunders. That is the kind of analysis that helps advance our knowledge.

Much of these four issues are woven through the three previous presenters, but our group did well and I am looking forward to this afternoon.

MR. SPRINGER: On the land use issue, we talked about a lot more than just economic issues, how it affects our lives.

MS. WILLIAMS: Right. The only other comment I want to add is if you look at three of the four points there is a common thread in each. From the perspective of getting to know the user of the system, building transportation systems that meet the requirements of the user is very important. It embraces Groups A, B and D.

I would like to underscore what Gary said about involving our consumers of the system. We found in the equity issues that these people have not been fully involved in the process because of the types of political forums used. There may be a need for different methods to reach that audience.

PANEL DISCUSSION ON POLICY ANALYSIS AND RESEARCH NEEDS

Moderator: George Smith Supervisor, Transportation Planning, CALTRANS

MR. SMITH: Good morning and thank you again for being here. A major purpose of this particular panel is to provide a solid foundation for where we go from here. I would like to introduce the first panel member, Charles Goodman. Charlie has been a Policy Analyst with FHWA. His areas of responsibility include coordinating research between ITS and environmental impacts. He is also Secretary of the Energy and Environment Committee for ITS AMERICA. Charlie's first experience with FHWA was as a community planner. He spent 17 years with an MPO in Baltimore, the last four years of which he was the Transportation Planning Director. He has undergraduate and graduate degrees from Johns Hopkins and he is also Chair of the Transportation Planners Council and a Director on the Technical Council Standing Committee of ITE, the acronym for Institution of Transportation Engineers.

RESEARCH ISSUES

Charles Goodman Office of Policy Development, Transportation Studies Division, FHWA

MR. GOODMAN: Thank you George. As Tom and as George indicated, this session is a status report intended to be used as a starting point for discussion in the later sessions. I first want to summarize what happened at Diamond Bar, California, at the IVHS and Environment workshop held in March of 1993. Cheryl Little and I share presentation of the summary.

As the overhead indicates, the objectives of the Diamond Bar workshop were very similar to the program of this conference, promoting a better understanding of the interface between ITS and environmental issues and reaching a consensus on recommended areas for improvement. The Diamond Bar workshop focused primarily on technical issues -- data and modeling. You will see that it is impossible to totally separate the institutional, nontechnical kinds of issues from data and modeling interests. We could not ignore policy issues at Diamond Bar, nor can we here totally ignore the modeling and the data. We have already heard some reference to that earlier this morning. Modeling and institutional concerns do work together.

The emerging context that we faced in Diamond Bar was, by virtue of the ISTEA mandate for a more inclusive and responsive public involvement process, an emphasis on consumer participation and customer needs in transportation in general. We had a call to view ITS in the same way.

We also took a fresh look at the arrangement between ITS and the environment. The traditional environmental impact assessment model, as required under NEPA looks at all possible transportation improvements first and then determines which minimize or even mitigate environmental impacts. What we began doing in Diamond Bar was to flip that around and begin considering environmental quality the operative goal with transportation -- ITS strategies -- becoming the means to that end. We focused on what could be done to transportation system operations and the way travel demand is exerted on that system to improve environmental quality. So it is not simply a mitigation of environmental impacts. It is more how we operate the system to improve environmental quality. That certainly is a central theme of the program today. We first began discussing that context at the Diamond Bar workshop.

The Diamond Bar workshop resulted in categories of recommended activities: 1) travel and environmental analysis, 2) making better use of the operational test program to learn about some of the impacts that we were attempting to project, and 3) developin, a better understanding of institutional issues or, as otherwise labeled, nontechnical issues.

In Travel and the Environmental Analysis, three key questions emerged: 1) Will ITS reduce, induce, or make no significant change to emissions? 2) What can we do to deploy ITS in a way that directly leads to emissions reductions? 3) What do we need to do to our analytical systems to get a better handle on ITS? What that led us to was a lengthy discussion of the need to integrate the traditional planning model with traffic operations models, and with follow-on emissions model. In an even broader context, we may consider land use as the very first step and urban air concentrations as the very final step in this extended analytical construct. This amounts basically to a blending and a linking of the model frameworks, which Cheryl will talk more about in a few minutes.

To make better use of operational tests, there are two approaches. First, that we modify existing and planned field tests. That modification had to do with turning up the range finder on the camera and re-focusing the microscope to learn as much as possible about user response and environmental impacts from the various operational tests. Some operational tests lend themselves more readily than others to that assessment. For the most part, operational tests are narrowly scoped controlled experiments, which are, in many cases, so narrowly defined that it is almost impossible to detect measurable environmental impacts. Nonetheless, not enough attention had been paid to that issue and therefore we recommended a fresh look at the operational tests. There is a lot happening in that area now and I will summarize where we are in implementing these recommendations shortly.

The second sub-item under operational tests concerned the initiation of new experiments with environmental quality as the operative goal. As you may have heard Denny Judycki mention yesterday, 17 new operational tests have been awarded -- three of which deal directly with emissions detection. I think we have already made progress in implementing that recommendation.

The third category of recommendation related to institutional issues. Three sub-themes emerged from discussion at the Diamond Bar workshop. First, it was recommended that ITS environmental research programs be developed from social decision analysis -- a process of engaging the customers or end users of the service in the research and evaluation process. In fact, we have already heard this theme from a couple of the breakout groups. The second institutional issues item recommended was the notion of making a broad agency announcement and solicitation for future research. Here the intent is to engage a broader community beyond the traditional transportation consultant teams in evaluating ITS impacts. Thirdly, the whole realm of interagency at the federal, state and local levels was identified as being in need of greater attention.

Regarding model enhancements to improve analysis of ITS, the Travel Model Improvement Program, referred to by the acronym "TMIP," is a comprehensive program of outreach and training on current analytical methods, as well as near-term and long-term schedules for improvements to the model structure and associated data systems.

A prominent feature of the longer range modeling element is the TRANSIMS project. This research has the potential to significantly improve our ability to analyze the travel and environmental impacts of ITS strategies. TRANSIMS will involve a holistic simulation of individuals' travel decisions -- from deciding whether or not to make a trip and the associated underlying factors, to the destination, travel mode, and route. This will expand the traditional route choice focus of ITS and allow analysts to assess the impact of providing information before, as well as once a trip has been made.

Next, I want to summarize recent research on institutional issues. An effort over the last year and a half by the firm of Booz, Allen and Hamilton looked at the institutional barriers to traffic management at the metropolitan area level. Six case studies were selected in which interviews were conducted with state and local officials looking at the feasibility and impediments to regional traffic management. Limited expertise in ITS, the need for more information, and the need for improved evaluation methodology were identified as impediments to the regional process. The Report to Congress on Nontechnical Barriers raised many of the same issues, such as the importance of coordination, outreach, and partnerships.

Currently being planned are a variety of deployment support and institutional issues research activities. Informational workshops in six regions are planned with a focus on public private partnerships. The National ITS Program Plan has been discussed previously in this conference. The current draft proposes a 29th user service focusing directly on ITS technologies as a means of emissions detection.

Another emerging area of research, addressed by Carol Zimmerman yesterday, focuses on user acceptance and willingness to pay.

New areas for ITS research include societal issues and the effect of ITS on disparities between population segments.

ITS deployment and the planning process will involve another series of case studies about half of which will focus on nonattainment areas. This effort will look at how the planning and policy development processes consider ITS in an air quality nonattainment area.

MR. SMITH: Thank you, Charlie. The next speaker is Cheryl Little. Ms. Little is an Environmental Analyst with the Volpe Center. Her primary responsibility is assessing the environmental impacts of ITS user services. She has a Bachelor of Science in Chemical Engineering from the Colorado School of Mines and a Master's Degree from the Fletcher School of Law and Diplomacy where she specialized in economic development and international energy policy.

RESEARCH ISSUES

Cheryl Little Environmental Analyst, Economic Analysis Division, USDOT

MS. LITTLE: Charlie Goodman asked me to talk about the research projects that are being funded by the Federal Highway Administration. In particular, I am going to address three projects that touch on a number of the modeling and analytical issues from the last year or two and have also been raised in the breakout sessions. I will talk about: (1) the ITS Benefits Assessment Framework; (2) a guidebook to assess the energy and environment impacts of operational tests; and (3) the development of modal models, which address the emissions and fuel consumption impacts of smoothing traffic flow.

I will try to talk about these projects in a broader context and use them as a platform to address related research which other organizations are doing. I will also address our projects in the context of some of the research goals that were identified at Diamond Bar. These goals are listed on the screen and I will not address them in detail.

First, Diamond Bar emphasized the integration of traffic, air quality, and travel demand models. This research issue not only confronts the ITS community; but conventional traffic projects are also trying to grapple with how to merge transportation and air quality disciplines. Secondly, Diamond Bar called for explicit evaluation of emissions impacts from ITS operational tests. We must leverage as much knowledge as we can from those tests. Thirdly, Diamond Bar stressed an issue that also came up yesterday, incident management and its potential benefits. Fourth, Diamond Bar recommended the development of realistic driving cycles, which addresses the impacts of smoothing traffic flow. Fifth, Diamond Bar recommended an increased focus on trucks and buses by improving environmental evaluations of CVO (commercial vehicle operations) as well as advanced public transit projects. Sixth, Diamond Bar called for new alliances particularly how can we start to work with EPA, DOT, and the environmental community to resolve a number of the technical issues.

So, in the context of Diamond Bar, let me first address the Benefits Assessment Framework. It is a two year project to develop a model-based framework to assess ITS user services. We are evaluating environmental impacts in a very narrow sense by strictly assessing impacts on vehicular emissions (primarily those that have been targeted by the Clean Air Act) and fuel economy. We are also looking at impacts on congestion and safety measures.

The model-based framework integrates a number of different models: (1) travel demand models that predict travel behavior choices with respect to trip-making, route, and mode choice; (2) traffic simulation models; and (3) three different impact models that address impacts on emissions, safety, and fuel economy. We are using this framework to look at relative changes in environmental measures due to changes in the number of trips, mode choice, traffic flow patterns, and VMT.

There are two issues I want to point out which concern modeling of ITS user services. First, the models must consider that travelers receive different information; not all travelers have the same information and not all of them are going to use the information in the same way. The second aspect, which is important to model, is ITS's real-time nature. For the framework, we have tried to make the models more dynamic.

Right now the Benefits Assessment Framework is oriented to look at traffic management user services: signal coordination, ramp metering, integrated traffic management, and incident management. We have oriented the framework to look at a test bed in the San Francisco Bay Area. One of the issues we recognize is what you compare ITS with; we have been very strict in ensuring that we compare ITS to conventional traffic management systems so that we can assess the incremental "bang for the buck" relative to systems that are probably already implemented in a number of cities. This is very important. For example, we recently reviewed an Australian study which looked at demand-responsive traffic signalization. They compared demand-responsive traffic signalization to no area traffic control and found a fourteen percent improvement in fuel economy. Then they compared the ITS service to fixed-time (conventional) traffic control and found a six percent improvement in fuel economy. So the benefit was reduced by half. We must, therefore, be very cognizant of what the baseline is.

Right now we are running our framework and have pretty much cranked through a number of the cases. The results are showing, in aggregate, for a 40-mile long corridor, improvements in emissions and fuel economy in the area of five to 15 percent.

One of the issues we have been dealing with is the noise in these models. What are the error bars? When we look at the network on a link by link basis, we know that some of the links are showing higher improvement and some are showing lower. I think a comment that came up yesterday was very appropriate -- I think it was brought up during the lunch session--which was that professional responsibility requires that when we publicize results, the audience must have some sense of the confidence that is associated with them.

We are also going to extend the framework to look at pre-trip planning and en-route information as well as public transportation services. We have been working with the FTA and others to try to accomplish this.

Let me now touch a little bit on the drive cycle and emissions and fuel use modeling effort. This project came about because of the Benefits Assessment Framework. Most of the user services that we are evaluating are not going to have a major impact on trip-making or mode choice. Essentially, the traffic management services improve congestion levels which will hopefully smooth traffic now. What are the emissions impacts from the smoothing of traffic flow? That question was brought up yesterday. There are some significant benefits that can be realized by reducing idling and reducing hard accelerations. We are developing a model to address this.

We started down this modeling path a little bit last fall. Let me point out that there are a number of efforts going on around the country to try to develop modal models. We identified at least I5 different institutions that are trying to develop modal emissions models. Two of them are represented here by Simon Washington and Matthew Barth, who have papers in this conference's proceedings. We have also found that there is no off-the-shelf model to deal with emissions as a function of changes in traffic flow. As a result, the DOT is entering new terrain. By necessity, the Volpe Center has a pretty concerted outreach effort.

Right now, we are coordinating with FHWA's Turner-Fairbank Research Center, which is developing emissions and fuel factors for a microscopic traffic simulation model, TRAF-NETSIM. We have also approached Oak Ridge National Lab who is working for Turner-Fairbank, the California Air Resources Board, and the U.S. EPA. We have found that there are several EPA departments interested in our work, including the Testing and Certification Division. and the Office of Mobile Sources. We have also talked to the auto industry as well as academia.

There are two major issues with respect to modal emissions modeling: credibility and acceptability. Credibility requires us to ask when the model is good enough so that we feel confident that we obtain appropriate results. The other issue is acceptability, particularly with respect to how these models should be used for analysis. One of the issues that is come up is the TIPS and the SIPs. The EPA has required that the MOBILE model be used to support TIPS and SIPs. So, what does this mean for our modelin, efforts? How do we try to start bringing in EPA to participate in the development of modal models so that we can have a more refined analysis of ITS? We have not quite resolved these questions.

The third and last project I will discuss concerns better use of the ITS field tests. There is a paper, Lee Munnich tells me that there will be copies out in the lobby, written by the Volpe Center in which we attempt to assess the state-of-the-practice for evaluating the environmental impacts of ITS operational tests. There is probably, at a minimum, 400 field tests going on worldwide. We identified 40 field tests that have an environmental evaluation component. We have been asked by the Federal Highway Administration to develop a guidebook to recommend best practices for conducting energy and environment analyses at ITS field tests.

In the paper, we also identified a dozen field tests that have published results on the environmental impacts of ITS user services. The studies have been positive and, in general, have favorably viewed ITS, particularly dynamic traffic control systems. The studies suggests favorable impacts of ITS on emissions and fuel consumption There are still many ITS user services that have not been evaluated, public transit for instance, and a number of the commercial vehicle operations.

For the guidebook, we are developing a proof-of-concept with the thought that there can be a generic framework with which to evaluate operational tests. Based on the proof-of-concept, we will prepare a guidebook that can address a wide range of ITS user services and hold a national workshop for field test participants.

I will conclude by issuing a plea. If there are individuals here who are interested in acting as a sounding board for any of the projects that I have talked about, we are very much interested in getting input as the projects develop. We want to ensure that the projects meet your needs. Thank you very much.

MR. SMITH: Our next speaker is Edith Page. Ms. Page is Manager of Infrastructure and Transportation for the Bechtel Corporation. Her areas of responsibility are transportation, environmental and other public infrastructure. Prior to joining Bechtel, Ms. Page served as Director of Transportation Projects of the Congressional Office of Technology Assessment. Ms. Page has served as a Division Council Member of the Transportation Research Board and on transportation advisory committees. She holds degrees from Oberlin College and Columbia University. Ms. Page.

SOCIETAL IMPLICATIONS

Edith Page Manager of Federal Programs, Bechtel and Chair, ITS AMERICA Societal Implications Task Force

MS. PAGE: My remarks today are clustered around the theme of responsible policy and a better rounded research agenda. You have all been too polite to ask why societal implications are on the agenda of an environmental conference. In my mind, environmental and societal issues are very closely linked because they are both intrinsic to the quality of life and to making sure that all of us, whether rural or urban dwellers, are able to enjoy a high quality of life. Environmental and societal issues are also linked by the fact of early neglect in the rush to develop technologies for ITS and by the imperative to reach out to non-ITS or ITS traditional constituencies.

I am also here to learn from you by listening because the state of societal implications research is, to be very polite about it, nascent or embryonic. I have already heard a great deal of interest at this workshop starting with the quote that Barbara Richardson put on the screen from GE, from, I remind you, 1972, 22 years ago. Let me mention it again because I think it should serve as an object lesson to all of us as we go away from this conference to try to implement some of the things we have learned.

The quotation was that societal concerns need to be addressed very early, when they first arise. If they do not, they become political issues. Once they become political issues, they tend to lead to legislation and/or regulation. Once legislation or regulation is in place, we have litigation. The potential for this trajectory leading to lawsuits has already cast a slight shadow over ITS in areas of liability, privacy, possible environmental impacts and other societal issues. It is unwise to duck these political policy issues. If we do, they will attack us and bite us from behind.

I have a few modest suggestions for a research agenda that I want to lay before you today. Before I begin on it, I should say that my job for almost a decade when I worked for Congress was boiling the very complex down to the simple so that I could state it briefly enough that a Member of Congress would stay awake to listen to it at hearings. So I got very good at being inclusive in my overall statements.

In that spirit, my overriding concern for a societal research agenda is equity, equity of access to ITS, and equity in benefits and costs. Let me elaborate a little bit. First, how will ITS affect a mixed multimodal transportation system in which some are ITS users and others are not? We must think of all of these constituencies, including bicyclists and pedestrians, who may not be using the technologies but who will be affected by them.

Attention should be given to evaluating the ways these might interact, these different parts of the transportation system, as they are enhanced by ITS or ITS to optimize the workings of the system. Second, to adopt Lisa Saunders' warning of yesterday, the impacts both positive and negative, of different ITS technologies on different social groups must be analyzed. Here I want to make a pitch for including political and social scientists as well as economists in ITS research. To date, we have seen relatively few social and psychological studies done of transportation or ITS. That is an oversight that needs rectifying.

Is there a way to ensure that ITS lessens rather than heightens social and economic differences between literate and semi-literate, the physically capable and those with disabilities and the highly skilled technically and others? We know that a high correlation exists between literacy skills and economic status. The costs of such economic disparity are high, when one looks at any inner city in this country and abroad. ITS does not and will not cause this disparity, but it may exacerbate it if care is not taken. One outcome of this may be that cost or benefit transfers are appropriate or necessary, and this possibility needs to be analyzed. If special education programs are necessary, who pays and who buys equipment?

Equity issues of public access to the benefits of ITS are many and various. Let me give you a real life example from the height of the summer travel season last year. There was a 20 mile line at an exit on the New Jersey Turnpike because of a backup from the toll booth. If we had implementation of ITS, there would have been a separate line through which people with the capability could have taken their cars. Others without the economic means or the forethought or with faulty equipment would have had to remain in the line with the attendant consequences.

What are our options for assuring equal access, particularly on down the line when we have aging equipment? First of all. we have a very long time before the benefits of ITS are realized throughout the fleet, and that needs to be taken into account. We have witnessed this phenomenon in the improvement in air quality, and one of the major ways to address that is posited now is to take the remaining old cars off the road. It is going to be a similarly long time before we see the benefits of ITS, and by the time we do that, many of the early cars outfitted with it are going to be old and in poor condition. These technologies are going to be hard to maintain; they will be in used vehicles, and they will be long in the economic strata of owners where the maintenance is an additional problem because of the costs. How are we going to deal with this? What impact is this going to have on the overall fleet performance? Are subsidies appropriate under these circumstances? If so, how should they be collected and distributed? Who is eligible and for how much and who should bear the cost?

Then we come to travel choice issues. Transit managers feel ITS will make it more convenient to use transit so that ridership will increase. This probably will happen. Latent demand by auto users may well fill in the slack, but that does not matter, the system is still carrying more people, more miles.

Even if transit use does occur, other travel changes will also occur. What are the implications if ITS makes auto travel much easier in urban areas so automobile use jumps substantially? What are appropriate land use planning and other practices? Is it possible, is it politically possible to use congestion pricing for environmental and air quality control? I am not sure that it is. There are some studies that show that doing so is such a difficult political lift that it is not very practical to think about it, except, perhaps, on brand new facilities where the increase in capacity is so overwhelming that the extra cost seems worth it. What are the likely environmental consequences of major shifts? What will be the effects on air quality, on travel amenities and aesthetics, and how do we acquire the political will?

Safety and health implications -- at the simplest level new types of accidents will occur with ITS. That is what always happens. You see it in air traffic control all the time. A new gizmo is introduced and until the pilots and remember they are highly trained and selected for their capabilities -- become used to it, they have accidents with it. The same thing is going to happen with ITS. We must anticipate and conduct research toward developing proper counter measures. Again, who pays?

Legal, privacy and enforcement issues are already receiving more attention than health or social issues. Here, too, programs need to be developed that can lead to embrace of the promise of ITS and the changes it will bring to traditional enforcement.

Yogi Bera, among a number of his other well known quotes, is reported to have said, "no matter where you go, there you are." Even if he did not say it, I think he ought to have. I submit that if we do not develop a robust research program that looks at where we are going with ITS, we may end up having paid a lot of money to reach the promised land and find ourselves wishing, we had done things quite differently. In whatever way this fits you, please take it as a challenge.

MR. SMITH: Our next speaker is John Kessler. John is an Economist with EPA. Most recently. he worked on the Clean Air Act Transportation Conformity Rule and led the development of transportation sector strategies included in President Clinton's Climate Change Action Plan.

Before joining EPA, John worked for the City of Cambridge, Massachusetts, and founded a small computer software company. He is a graduate of George Washington and has a Master's Degree from the Kennedy School of Government at Harvard. I hope that all of you have the chance to check into John's latest paper, Meeting Mobility and Air Quality Goals.

ENVIRONMENTAL REVIEW PROCESS

Jon Kessler Economist, Office of Policy Analysis, EPA

MR. KESSLER: I want to talk about the topic that I think of as a subtext -- it may not even be a subtext of this conference -- that is: how do we get the environmental community on board the ITS bandwagon and talk about the environmental process as part of that? My speech is clustered -- I like that terminology -- around two topics. One is assessing the environmental impacts of ITS and the second is finding ITS applications that have environmental impacts.

The first of those topics, I would start by giving the ITS community tremendous credit. Clearly this group takes the Clean Air Act and other environmental laws, NEPA, very seriously. It is amazing to me to see the amount of energy and the number of dollars -- the bottom line -- that have been devoted to the topic of assessing the environmental impacts of ITS. It is incredible and it is something for which both DOT, ITS AMERICA and the entire community ought to be congratulated.

However, and there is always the however, in any speech that the EPA gives, and certainly that I give - the problem as of now, and Cheryl Little alluded to this, is that to a great extent energy has been focused on attempting to reinvent a wheel that we have been tilling at -- to mix metaphors -- for more than 20 years now. I heard someone say yesterday, and some of you heard my reaction, that environmental modeling and environmental assessment had not made significant advances since 1970. To me that says that the person making that statement has not spoken with or has not had significant and substantial and lasting contact with either EPA or members of the environmental community over that same period of time. Because the fact is that the folks who work at EPA -- and those of you who know me know that I am a bit of a cynical sort -- but the folks who work at EPA and at the California Resources Board and throughout the environmental community are not stupid people. They are not people who do not understand that the modeling that they use and the assessment tools that they have are inadequate. They are working very hard with limited resources to deal with those issues.

It might surprise you to know -- and this shows that I am a bureaucrat when I talk about budgets -- that the budget of the entire Air Program at EPA is probably eclipsed by the budget of the ITS Program at DOT. It gives you a sense of the resources that we have. What does that mean? That means that from the perspective of environmental assessment, I think that the best thing that the ITS community can do is -- and in some sense the fact that it has not been done is a failure on my part since it is my job to make sure it happens -- is to start talking in a serious way, in a way that involves resources and real energies to the folks at EPA and at other relevant environmental agencies who have been doing the hard core environmental assessment for years now. We know, as do you, that a modal emissions model would be somethingthat we would love to have and we have been working to develop one for years. Why do not we have it? Well, there are complicated answers. For example, we are not sure that even if we did develop the data we had that we could actually produce a model that would be statistically robust in predicting modal emissions. There is also one very simple reason and that is the data needed does not exist.

Why do those data not exist? Because -- and this is I think the irony of it -- the technology needed to collect them, technology that I think fits well within the realm of ITS has not been applied to this purpose. So here is an example of an area that I think is in many ways at the heart of ITS where this community could be making a real contribution. One that everyone in the environmental community, at least in the air quality community, would view as a tremendous advance. That is helping us develop the technology that we need to make better models, as opposed to trying to use the same data that we have been using for years to try to invent new models -- in a sense reinvent the wheel. If one looks for models of cooperation, the sad part is there are very few. In part that is because we at EPA and elsewhere in the environmental community are sometimes a bit arrogant and also a bit protective of our analytic methods. We are attacked quite often in the same way that I imagine the ITS community is somewhat protective of ITS technology that is sometimes attacked by people who do not know that much about it. So the trick is to find ways to get over that and to work together. 1 do believe that there are real gains that we can make

together in the area of environmental assessment, gains that do not simply amount to the ITS community convincing the environmental community that what you are doing is not so bad for the environment or is good for the environment. but amount to improving ITS and applying ITS to improve environmental assessment.

I should say before I leave this little subtopic, that one example that I think is nascent, but where we are seeing that kind of cooperation is this Travel Model Improvement Program, or TMIP that Charlie mentioned. Here is a program that is fundamentally a DOT program, a program that we all agree is desperately needed, but it is a program that certainly had the potential to look to EPA like someone else trying to think that they were smarter than us, but using the same technology that we had. In fact, what has happened is that the folks who were involved in the advanced work as part of the TMIP from Los Alamos Labs and from DOT and elsewhere have made the effort, have gone to Ann Arbor and met with EPA's folks. They spent a lot of time trying to delve through data, trying to explain painstakingly to EPA's experts what it was that they were trying to do in the way of forecasting emissions from travel behavior. I think that we see the beginning of a fruitful relationship there. If we try hard we might see an even better relationship between the ITS community and the folks at EPA and elsewhere.

Let me turn briefly to the notion of ITS projects that have environmental impacts. One of the things that I am very encouraged about is that whereas we spend a lot of time debating the relative merits of traffic flow improvements -- and frankly you will never convince the environmental community to get all excited about traffic flow improvements -- we see that ITS is much more than that. If we are going to bring the environmental community on board we need to broaden ITS even further and we see that here, the effort to find projects, specific ITS applications, that have direct relevance to improving environmental quality.

I will give you one tip in closing to do that. You are going to have to get beyond those of us in the environmental community, myself included, who, in their heart, are transportation people. We want to talk about transportation projects, but there are a lot of people out there who you will never see in this room who have basic environmental or air quality projects that have in many ways nothing to do with traffic flow improvements or travel demand management, but cry out for the application of ITS technology. So, in part, the trick is to use people like me as a resource but to get beyond us as well, to find ITS applications that the environmental community as a whole can say are good things and can get behind.

MR. SMITH: Our final speaker is Monty Hempel. Monty is an Assistant Professor and Director of Public Policy Studies at the Center for Politics and Economics, Claremont Graduate School. There are at least two parts to Monty Hempel. His theory driven part deals with the qualitative modeling of international environmental governance issues. That is the theory driven side of the house. The practical side of Monty Hempel has to do with the day to day policies of transportation, environment and community.

Prior to joining the Center for Politics and Policy, Monty was a candidate for United States Congress from California's 33rd District. He has consulted on land use planning and he has participated in several environmental conferences including the 1992 Earth Summit in Brazil. Monty has several publications. He has a Ph.D. in Government and a Master's in Environmental Policy from Claremont and he has a B.A. in Ecology and Public Affairs from the University of Minnesota.

POLICY AND PROGRAM IMPLICATIONS

Lamont Hempel Assistant Professor for Politics and Economics, Claremont Graduate School

DR HEMPEL: I do not know which part of me is going to address you today. I find that we all have predispositions when we come to the issues of ITS or just about anything else and my own predisposition is that of a social scientist. I find that conferences like these are almost always frustrating because in front of me are at least three types of people. I will just get a sense of how many of each type there are here. There are the "techies," those of you who have essentially an engineering or science training or orientation. There are the "fuzzies"-- I prefer "talkies" actually to keep the alliteration here -- social scientists and people with liberal arts backgrounds and so forth. Then there are the "tweenies." I like to think of myself as a tweenie. somebody who works back and forth between these two orientations or cultures.

I am going to talk a little bit about what I see as some broad themes -- I am going to have to do it pretty quickly -- that involve how people who study policy and institutions might be helpful in looking at ITS kinds of issues. In my view, we have three levels, or overlapping stages, of development in advanced transportation technologies starting with the movement of vehicles as stage one. Increasingly, we are trying to concentrate attention on the movement of people rather than vehicles. Those of you on the telecommunications cutting edge are talking about the movement of peoples' thoughts and their images. This is the old idea of telecommunications substitutes for business travel, but increasingly with things like video-conferencing and so on a lot of our transportation needs can be met with our telecommunications technologies.

From an environmental point of view, the environmentally correct movement is toward that third stage wherever feasible, wherever convenient at least, to reduce the number of trips, to reduce the amount of congestion out there from people trying to make trips.

Now, one theme that is becoming very clear, and we have heard a fair amount about modeling this morning, is that we are having difficulty getting what are called tightly coupled models, system-wide models of modal choice, of trip generation and distribution, of on road driving behavior, of vehicle emissions, pollution dispersion. Putting all this together, which involves not just the physical modeling but the social scientists coming in and telling us about on-road behavior and trip generation, distribution and so on, putting all that together is very difficult. At the same time, we want a loosely coupled technology, a bundle of technologies. So we want tightly coupled models; loosely coupled technology.

Why? Well the person who has done I guess the most recent research on this is Hans Klein at MIT who basically argues that we need loosely coupled technologies because we do not want interaction of one subsystem with another subsystem to bring down, in a cascading fashion, other subsystems in our bundle of technologies. We have some good social science research on this, case study material basically of what happened to the space shuttle program, what happened to the super conducting super collider program in Texas, what happened to the SST program. These are all indications of what happens when you get tightly coupled technology systems.

In Hans Klein's terms, what happens when you have this tension between institutional interest and technological functionality? The institutional interest often prevails. We all have our own institutional interest. California PATH has an interest in advanced vehicle control systems as a steering behind their policy interest. The Federal Highway Administration is more interested in ATIS presumably. The Congress, to get a lot of the ISTEA packages through right, had to deal with rural applications so advanced rural transportation systems come in. These are all institutional interests that have to be somehow wedded in an arena where you who are the techies say, "But technical functionality is all that matters." And the institutionalists come back and say "yes, but politically you have got to put these other things in." And it ends up looking like an elephant mixed with a giraffe mixed with a hippopotamus.

This viewgraph is very simple. This is my home based model of institutional relations. You could also say it is the bulls eye for a target if you are an interest group that does not like ITS. But the idea here is basically that the relationship between U.S. DOT, ITS AMERICA, the state DOTS, the MPOs and most importantly the ones that we have not talked much about, and George gave me an entree here, cities and counties that so far are not tightly coupled in the institutional sense with what is going on here.

Somebody stole my line yesterday which is that all deployment is local. All politics is local, all deployment is local. And so, one of the things we do not have very good tracking on in our research on the policy side is what is going on with those cities and counties who have yet to get involved in this program.

Notice I have two circles here. The first one is the attentive public. The second one is the general public. Remember that that first circle contains less than one percent of the population, less than one percent of the population. So 99 percent of who has to eventually be reached are in that outer circle. Notice, too that there are some gaps. Gap one is the media, the role of the media as an amplifier itself, as a distorting influence if you like, but one that we have not talked much about at conferences like this. Social scientists will speak with some authority about how important it is to make sure that the images that the people in that second circle receive are images that are not distorted.

Advocacy coalitions, a term that does not get used at ITS meetings very often, are another important influence. There is a difference between interest groups and advocacy coalitions. Advocacy coalitions are there for the long-run. You have to understand environmental groups are not interest groups. They are advocacy groups. They will not put everything on one battle. They are going to be here year after year after year. This is not a fad. This is a long-term movement, one that I am a member of and proud to say so. Therefore, one has to treat them as long-term partners, not "can we come to the table on this issue," but "can we form a long-term sustainable partnership with environmental groups to work out what are inevitable conflicts and tensions?"

Just a quick look at one way of looking at this problem. This viewgraph is a constraints map, a very simplistic constraints map, but nevertheless a constraints map which talks about -- I guess that is not readable -- constraints of knowledge, cost, the hardware, the political support, the ecological carrying capacity, etc. All start out as generic constraints. Then we have to choose the institutional strategies that we are going to employ. Is it going to be primarily private led? Is it going to be primarily a public/private partnership? Is it going to be primarily a government led technology push or do we have the option of do nothing and then you see we get public pressure because of things like congestion, forcing government to do something. So that is not an answer.

What are the limitations on each of these institutional strategies? Well, the first one, pre-commercial start-up problems for the private sector doing it all themselves, is obvious to most of us sitting here. In public/private partnerships, the limitation is the lack of cooperation that is involved in having cultures, organizational cultures that are fundamentally different. Thirdly, the government limitation, the technology push side. Here, we have a variety of problems, but most importantly the inability of government to have enough foresight to steer an economy or to steer a technology, or to plan their remarks with only two minutes left to get it all in. Procurement issues would be another one that is important here.

Then we have the collaborative framework, ITS AMERICA, U.S. DOT at the national coordinating level; the enabling legislation, ISTEA; and then we have the problem of conformity with other goals. We have the Clean Air Act Amendments, we have the American Disabilities Act, we have the Energy Policy Act, we have deficit reduction programs. All of these are external forces that you are aware of I am sure, but we do not spend much time tracking just how importantly they affect what happens with the implementation of ISTEA and how goal conformity ends up being a very important stumbling block.

I will conclude by saying that Tom Horan and I are involved in a project in California looking at the policy and institutional implications of ITS in that state. One of the things that we have found in the research and in the interviews that we have done over the past year is that stakeholder analysis is a very vital part of the policy research agenda that has to be put together. We found in California, for example, that environmental groups are probably the single most important stakeholders in the ITS debate. The question of how to get them to the table and how to

make sure that they get information that is not distorted or not overselling ITS but just good honest analysis is a very important part of what has to happen. These kinds of constraints mapping exercises can help show where those various stakeholders operate. We also have to look at the problems of research collaboration, how you form partnerships. I know there are a lot of people here who have looked at that, but I trust that we can bring in some case study materials that will show that there are some lessons that can be drawn from past efforts to develop technologies and we do not have to recreate this wheel each time we come up with a new set, a new package of technologies.

Finally, I did not get to mention on the graph here, but when we try and remember that one percent of the public is attentive to ITS, less than one percent, that suggests that polling techniques of finding out what the public wants or what the consumer needs are very limited. There is a new technique called deliberative polling which is much more promising in my view. A political scientist named James Fishkin has been working on it.

England, for example, has recently developed a major deliberative polling exercise where they bring in a stratified sample of the public, selected randomly. They are brought together for a three day period, they are paid. They are allowed to cross examine experts by the hour from various perspectives on very complex technological situations or decisions like ITS deployment. In that three day period, the learning curve is pretty steep. There is a lot of learning that goes on, and then the survey approach is tried. You get much more meaningful information and that deliberative polling is something that it is time to apply to ITS in terms of public and environmental concerns.

QUESTION AND ANSWER SESSION

MR. SMITH: Are there three or four people with questions that will require only a minute answer a piece?

MS. SAUNDERS: I am happy to hear that DOT is looking at public transportation, because in my study I found that members of disadvantaged communities were two to three times more likely to use public transportation. I also learned a lot about cross subsidization in some cities where disadvantaged users of public transportation might be subsidizing rail transit by middle class commuters. So I would like to hear what are some of the DOT questions around public transportation and how ITS will affect that. Some of the answers, if you have gotten answers yet.

MS. LITTLE: No answers yet. We have concentrated first of all on the traffic management services and working our way to public transit. Right now it is just a question of trying to work out what the appropriate cases would be to look at public transit user services, because they have quite a range of types of services from smart cards to pre-trip information, kiosk information. So those types of issues have not been resolved. That is why at the end of my talk I basically gave an invitation. If there are some particular types of strategies or interests, to let us know that we can begin to address in our analyses.

MR. J. MILLER: My name is John Miller. One of the things that I have heard mentioned several times is that there is a lot of work going on in the modeling area, a lot of different types of models being done by a lot of different organizations, a lot of research in that area. One thing that EPA has done is they have established a bulletin board where users from around the country can get in as a central source of information for the Mobile and some models in that area. Does U.S. DOT have any plans to develop a similar say bulletin board for research on the various models besides the ones that EPA is involved with such as the California and some of the ones involving the operational tests?

MR. GOODMAN: We at DOT utilize various bulletin boards. Do we have one dedicated for modeling and data? At this point we do not, but that is an interesting sugg

Given the larger community of stakeholders interested in this, it is something we will look into.

MS. LITTLE: One thing I want to point out there is that we had talked about trying to develop a national database to start trying to coordinate the information coming from the Op test, and that was, given resource constraints, was put on the back burner but could be revived for some upcoming projects.

MR. MARING: Gary Maring, Federal Highway Policy Office. A question, I guess particularly for Monty Hempel, related to the public/private roles in implementation. We talked mostly about the public side issues, environmental, societal and other kinds of issues. We have not heard too much from the private sector and the marketplace issues and timing of implementation. I see a pretty wide disconnect between the private sector and their desire to get rapid implementation of some of the ITS technologies that are ready to do. Yet the public side, and what I have heard over the last day and then this morning on some of the data and modeling and all of those issues, it sounds to me like we have an incredibly long time frame here getting all of the models and the data and the analysis from the public side that are going to be necessary to allow the ITS technologies to move on. On the other hand in the private sector, there are some obvious things that will move ahead, even that do not require governmental intervention or environmental analysis, like in the freight sector that are already being implemented with GPS and other kinds of technologies.

I do not know, I see a real disconnect between the public and private sectors on the implementation of ITS technologies. I see a lot of things that are probably going to go quickly in the private, particularly in the freight market. On the other side, some of the personal transportation things that have more of a government role are going to take an incredibly long time. How do you see, do you have any comments on resolution of the public and private interests and roles?

DR HEMPEL: Well, I guess I can only give you a very general comment on this, but time is short, change is slow. The basic problem here is that we see public issue attention cycles and those issue attention cycles go in and out with issues like congestion. In the Los Angeles area where I am from, congestion is no longer at the top of the list of things that people cite as a major concern. It was number two just about three years ago. It comes in and out with other issues. So that is important because that affects the kind of political will there is for implementation. It suggests why it may be difficult to implement some of these things that require government as opposed to just the market to pull it.

My own sense is that the people who are the techies who see the market for technology and wonder why we can't just deploy it since all we need government for is to help in the implementation, are probably not recognizing all these other reconciliation acts that have to be done, the reconciliation acts of transportation policy with land use, with air quality, with energy planning and all these other things. So once you look at all these other goals that have to be reconciled, then to a political scientist the implementation being slow is not surprising at all. But to the person marketing the technology it is very frustrating.

I would just say that the only way you get quick implementation in this country when it involves a lot of government involvement is prices. What we have here is a slow motion crisis. Therefore, as a slow motion crisis, it does not move implementation very fast, even though you and I may know that our transportation system is in grave need of some reform.

MR. KESSLER: I want to make a brief comment on that too. Sometimes we overestimate the pace at which public and private economies implement technology. I mean about aviation and the fact that we all hear on not a daily basis, but certainly quite often about the resource constraints in aviation, how important air travel is and all the market incentives that are out there for our airlines to develop new and better planes and systems of managing them. On the public side, we have a system of airline management that is at least 20 years old and is severely antiquated. On the private side, the flagship of our fleet, the 747, some of us forget was first tried out in the 1960s. So I mean technology implementation is not a particularly rapid process and in many cases for good reason. So I choose to see the glass more full than empty.

MR. SMITH: Thank you. Two more questions.

MR. REPLOGLE: Yes. I would just like to follow on Gary Maring's excellent question. One of the areas in which government can play a most useful function is in coordinating and in setting standards and in providing leadership to develop more uniform approaches to commonly held problems. And we have all these operational tests going on around the country and it causes me to think back about -- when I look at the lack of good data collection in many of these operational tests, the lack of a good evaluation framework causes me to think back to the service and methods demonstration program that the Urban Mass Transit Administration was running back in the 1970s that produced a pretty sound body of research and was a cooperative effort between the federal government, universities, research labs and transit agencies and state and local governments. Can we not build on some of those successful models of the past in better coordinating our ITS operational tests, which albeit they are driven by pork barrel politics? That does not limit the ability of the federal government though to at least apply some reasonable judgment and standards to saving you have to collect decent data on certain types of things.

I see some real opportunities that right now are being missed to develop nationally coordinated things like the National Travel Panel Survey that could produce longitudinal data that would be valuable for all of the operational tests, that could help us address a whole range of transportation and community issues. This does not necessarily have to be done solely with federal dollars. There are a lot of models for cooperative partnerships with the states working with ASHTO, working with MPOs and their associations. Certainly ITS AMERICA, ASHTO, ITE, other professional associations and trade groups could work cooperatively to develop these things so it is not just the big hand of the federal government coming in and imposing a standard but working together to develop good stone soup. We throw a stone in the water and we ask everybody else to contribute their carrots and their potatoes and pretty soon we have gotten a tasty meal. Right now, we are not cooperating together and as a result ITS is at risk, our implementation of the Clean Air Act is at risk, our implementation of ISTEA is at risk and it is all because we are not working together effectively. I would like the panel to address that.

MR. GOODMAN: Let me start. Because I did not want to see the yellow card here saying two minutes, I shortened my comments. One of the pieces I slopped over pretty quickly was the major initiative now at DOT to tool up in a systematic way the evaluation operational test sites. I mean we have a three year, \$3 million project to bring on an overall coordinator for the operational test evaluation to which the work that Cheryl Little described a little bit earlier on the Guidebook for Emissions will feed, to which also another effort we have with the VOLPE Center looking at user acceptance experience at operational test sites will feed. That is just the tip of the iceberg. So your point is well taken. We have unfortunately maybe gotten a late start at a more centralized systematic consistent way of evaluating operational tests, but we are getting there now and it just takes time. Cheryl has some specifics to share.

MS. LITTLE: Yes, I will be quick. You mentioned the services in mass transit, the demonstration projects. There is a fellow at the VOLPE Center that actually was very essential in that effort. We have already started talking about using that as a platform for evaluating operational tests, particularly the emissions and field consumption aspects.

MR. SMITH: Thank you. One last question.

MR. PAYNE: My name is Steve Payne, I am with the Houston-Galveston Area Council. We are the MPO for the Houston area. My responsibility is for long-range planning and air quality conformity. I am not going to pretend to ask a question. I want to make about a 45 second statement, then I am going to sit down.

Primarily just three things. First of all, speaking for the local, regional areas and what is going on with ITS, basically the projects are primarily conceived and implemented for two purposes. One is basically for facility efficiency and that includes transit mode choice, improvement in flow and so on and so forth. Secondly, it is for data collection. Mr. Kessler and Ms. Little hit it right on the head, we need better data and that is what we are after with this.

ITS has its virtue and its place, but it is in the context of the larger transportation issue. It may be significant but it is rather small when you take a look at the dollars. As far as the public participation process, that already exists for ITS projects in our particular system. It is through the MPO as identified by ISTEA, it is through the long-range planning process and the TIP process that each project gets ranked, filed and debated at the local level.

MR. GOODMAN: Just a couple of points. I did not mention that it is the early deployment and Houston may well be a part of that. The ITS Early Deployment Program is an attempt to put seed money out there to all the major Metropolitan Planning Organizations to look to mainstreaming ITS. We are all facing that, particularly non-attainment areas are dipping their toes in the ITS water but being very careful because if they attribute substantial emissions reductions to technologies with which they have little experience and it turns out that they made the assumptions, then they are in a predicament with regard to their air quality plan. We have seen that for some time, is the need to promote ITS, at least in the policy arena at the MPO level. It is to be hoped that the empirical data will follow.

MR. SMITH: Thank you very much. Thank you panel.

DR. HORAN: Next we have a very distinguished panel to discuss models for cooperation. Let me introduce Gloria Jeff the new Associate Administrator for Policy at Federal Highways. We are delighted that she could be with us today to moderate this panel and also I understand join us at lunch. Before she joined the Department. she was at the Department of Transportation in Michigan for several years where she was Deputy Director of the Planning Department. She has degrees from the University of Michigan, both a Bachelor's and a Master's,

PANEL DISCUSSION ON MODELS FOR COOPERATION

Moderator: Gloria Jeff Associate Administrator for Policy

INTRODUCTION

MS. JEFF: I found it fascinating that the second from the last question in the previous session was concerned about how we are going to do cooperation. What I wanted to do as I stood in the back was go, well thank you very much Mike for that transition, we will now have the next panel come up and you can all go out for an eight and a half minute break in the discussion. Then we would have come back and probably answered that question among others about what are the models for cooperation.

There are a whole variety of the models for cooperation. Mike and others in the discussion previously began to talk about the fact that there is not some model that we can utilize for cooperation among all the cast of characters. Because not only do we need to be concerned with the institutional arrangements at each level of government, but we also have to be concerned about what it means for human beings on a day to day basis and what the models for cooperation are going to be for that.

In our session we are going to focus on the institutional matters and I know that at some point in the breakout sessions there will be some dialogue about how do we include those who are directly impacted and users of the system in our models of cooperation and the implementation and design of them. We find ourselves with an interesting situation where the technology is magnificent, it presents many opportunities for us. At the same time it is a two edged sword because it also represents an opportunity that, if not properly implemented and thought through will move us not quite in the direction that we had hoped to go and we may find ourselves suddenly having wonderful technology implemented and in place and not having achieved a number of societal and other goals for people that we had hoped to accomplish with the technology.

Back to the issue of models for cooperation. Today that we have a very distinguished panel, a very interesting perspective of ideas as we look at what are those models for cooperation. Our first speaker this morning is Hal Kassoff. It is interesting out of all the panelists, Hal is the one who did not give me a biography. Hal was probably the one who knows me well enough to know that if you leave Gloria with an opportunity to say anything about you that is unscripted there is no telling what will happen.

Discussant: Hal Kassoff State Highway Administrator, Maryland DOT

MR. KASSOFF: 1 believe I am here because, within Maryland, we began a program called CHART, the Chesapeake Highway Advisories Routing Traffic, which started in the low tech world and is now moving into the world of ITS, Advanced Traffic Management Systems (ATMS), and all of the rest of the alphabet soup that goes along with it. I also happen to be serving right now as the Chairman of a unique coalition in the country called the I-95 Corridor Coalition. I will talk about that, as well. I would like to close with some comments on the issues of institutional cooperation involving the environmental community, the transportation community, MPOs and the role of DOTs.

Our CHART Program started low tech because we had a dysfunctional system in terms of reaching our beaches on summer weekends, and we had a dysfunctional Capitol Beltway (which we still do). We had incidents out there that we were not very good at clearing up. To be perfectly candid, what got us into the ball game was a mandate from the Governor of Virginia, the Governor or Maryland saying the two states will get together and figure out how to manage incidents. I highly recommend incident management as a way to get into ITS It is a humbling down to earth experience. It avoids the pitfalls of sliding into the high tech world and not necessarily getting good at the basics like getting out there and setting up safe traffic control, managing the incident, clearing the road and diverting traffic. That, to me, is the only way to start.

We did that first by cooperation, breaking down barriers between our police agencies, particularly the Maryland State Police and State Highways. We now have a model of cooperation. Our satellite centers are located in state police barracks. A Maryland State Police Liaison Officer is located at our Traffic Headquarters, and so there is a direct interrelationship. We sit in their house, they sit in our house, we get along. It is teamwork. Believe it or not, the state trooper is happy when we arrive on the scene because we now help manage the incident. Our folks are happy about having the support of the state police.

The second model of cooperation is federal, state, local. Of course on the federal level is funding and without the financial support for the work that we are doing, we could not have gotten started. The real action is taking place at the state and local level. If you consider that ITS should apply to the most important routes in the system, namely your arterials, the states have to be in the ball game. As you know, the feds do not own and operate many highways. So it is a state operation game. I know state DOTs are "out" in the modem era, but if you talk about ITS and operations they need to be "in," they need to be engaged, they need to be committed and focused and not just talking about it.

Local government involvement is another issue. A lot of them got started with traffic signal systems management. A few have grown beyond that. One of the models in this region is Montgomery County, Maryland where they are as advanced as any in the country in the complete array of intermodal traffic and transportation management, bus system, highway system, signals, incident management, diversion, ATIS, ATMS, you name it. We are working very, very closely with them. Not every local jurisdiction has made the decision to get into collectors and minor arterial roads and make that kind of investment to do it. It is a major commitment that they have made. Of course, others like Los Angeles have done the same thing, but it's a big step for many local jurisdictions.

A third model of cooperation in the CHART Program is the breaking down of barriers between maintenance and traffic people. We started with a field operation clearing incidents off the roadway, low tech, highly focused on our maintenance people. That was a good lesson for traffic people who are the custodians of the high technology to be sure that the technology that they are procuring and deploying has meaning to the operations people, will have an impact, is not technology representing a solution in search of a problem. You can get wrapped up in technology, you can mismanage it and you can look awfully bad in the public's eye. So breaking down the barriers among operations people, maintenance people, traffic people is very critical.

Public and private sector cooperation--we rely totally on the private sector for a number of areas. We rely on the broad based media communications during the rush hours, radio and TV. We have extraordinary cooperative

relationships with them. We rely on the cooperation of the towing industry so that we are not at each other's throats as has occurred in some states. Of course the high technology vendors to understand what a practical operating system must do and the reliability that has to accompany it, the fact that 100,000 eyes could be watching every mistake you make.

So CHART is off and running. This fall, we will open our state of the art high technology statewide operation center, interestingly five years after we started. So we did not lead with our chin, we led with our feet and we worked out way up to our brain. We think we are going to have a total package of high tech, low tech and everything in between with a lot of cooperative institutional relationships working.

The I-95 Corridor Coalition has been another extraordinary experience. Virginia to Maine, the busiest corridor in the country, 12 states, 12 toll authorities, New York City and Washington, D.C. Breaking down barriers between DOTs talking to one another, which they did not always do particularly beyond adjacent states, between DOTs and toll authorities, among modes, highway agencies, railroads, buslines, airlines, the trucking industry. We have an Executive Board composed of the executive leadership of the 26 entities that I mentioned and a Steering Committee that embraces all modes, all agencies and is composed of the senior technical staff, the driving force of the Coalition. They make it happen through a multiplicity of teams and task forces and a very high energy level. The goal is that the transportation user in the northeast corridor on a real time basis will have a seamless user friendly system to deal with.

What is happening on that system real time? How can I interact with it and learn about what is happening and make transportation choices at the moment that are intelligent choices, that work for me as a transportation consumer? And across modes, across geography--a major challenge.

An issue I would like to address involves the transportation community versus the environmental community. If ever there was an area where the two communities ought to be in bed with one another, you would think this would be it--ITS --making existing systems work better. Alarmingly I learned a year ago that in the northeast, environmental agencies were questioning ITS because it makes the highway system work better, so more people may be drawn to travel on the highway system. Frankly, this is a losing hand for the environmental community and if they play it to its ultimate end they will be, I think, discredited in this one arena. They certainly have legitimate roles to play in many ITS areas, but making the highway system work better, getting the last ounce of efficiency out of the current system is something you would think would be common ground and it mystifies me that we would be on a course that implicitly says the more jack knifed tractor trailers we have the better it is because it makes the highway system less desirable to use. That does not make sense. Our customers will not buy it.

There is a danger of over planning for ITS. We got started in six months. The State of North Carolina came up and looked at what we were doinggot started in three months. You can also take the long slow route and do feasibility studies and planning studies and disengage your operations people while policy wonks and planners play with the concept. Get started. There is plenty of room for policy wonks and planners to be thinking about it in parallel while you get started. Get started with incident management. There is no reason why jack knifed tractor trailers should take six, eight, 10 hours to clear off a roadway.

The bottom line is this is a place where the DOTs working absolutely as a team with local governments, with police authorities, with neighboring jurisdictions need to break down the barriers and make it work. But the leadership, the energy must come from the owners of the systems, otherwise it is not going to happen. The owners of the major highways happen to be state transportation agencies and the people who are going to make this work are your operations people. So they need to be engaged, they need to be encouraged to get started, or we will not see ITS realize its full potential.

MS. JEFF: Our next speaker is John Cox. John is Chairman of the Southern California Association of Governments, SCAG. He is also the former Mayor of the City of Newport Beach, California. He is a member of the South Coast Air Quality Management District in Southern California and he is involved in their Interagency Implementation Committee. He has a host of civic involvement that have prepared him to talk about models of cooperation.

Discussant: John Cox Chairman, Southern California Administration of Governments

MR. COX: From all I have heard today, I am your token local government grassroots individual. I want to try to give you a little perspective on what we are thinking. I put this viewgraph up not for you to read, but for you to understand the mass confusion and chaos and so forth that is going on in the Los Angeles area where we have more people than we know what to do with. We have more vehicles and travel than we know what to do with. We have a land use constraint that is existing because of habitat conservation programs. We have a health hazard and we certainly have the air quality laws that are upon us and impacting us very severely.

Just to put in perspective what kind of situation we are dealing with, I want to point out that not 15 years from now we will be dealing with 20 million people in the region that we have to accommodate. The other figure to call your attention to is that even if we accomplish all of the goals for air quality, we will still have 10 million single occupant vehicles traveling around the region every day that our transportation system has to accommodate.

The current performance indicators of the plans indicate our population will be growing by 40 percent to get to that 20 million figure. VMT is forecast to increase 48 percent. People still desire to drive their own automobile. Road mile construction is expected to be 12 percent, and thus your average daily speed will be decreasing and certainly the hours of delay continuing.

On top of that, through the SCAG Mobility Plan, we have to achieve some mode shift goals that have been identified here and I just give these as a highlight. We are still looking to reducing single occupant vehicles and offer more transit and more telecommunications use. The Air Quality Management District has its goals in sight, how we are going to reduce emissions from what would be the baseline in the year 2010 down to what has been identified. Mobile sources is in the red, so they have just as much goal in mind to achieve than anybody. To put that in perspective in terms of what the air plan says that the region has to address is that we are looking for a 50 percent market penetration of electrical vehicle sales by the year 2010. If we do not sell one today, we are going to have to sell that many more in 2010 if we are to meet some of the air quality goals. The same is true for the 34 percent of ULEV, your natural gas and methanol vehicles. On top of that, the indirect source rules that impact the region and thus locally saying things like we have to reduce our trips to shopping centers by 12.5 percent, we have to reduce trips to special event centers by 10 percent, et cetera. All of us, when we are in a stage of significant economic impacts, how can we possibly be reducing our trips to our shopping centers if this is the kind of goal that is outlined here? Even a proposal that we go to a 2.5 AVR for employers with all the difficulty and the money that is invested in trying to achieve a 1.5 AVR.

Why am I pointing these out things such as shopping centers, business centers, and activity centers at an ITS conference? Well, some people say one of the key goals is that we ought to be looking at traffic flow in these arenas. For example, Disneyland currently has a 3.8 AVR. They do not travel in peak hour. They spend nine hours of time at the facility, why would they want to reduce and how could they possibly reduce more? A better way of getting at emission reductions could be better traffic flow through parking management programs using AVR devices to get there.

At SCAG we set up an Advanced Transportation Technology Task Force for the purposes of addressing these concerns because we sincerely believe command and control and behavioral change strategies are not workable. Almost \$200 million is spent every year on the car-pool program with employers with very, very little impact and success associated with it. This does not mean the technologies are going to be the solution either in terms of the consumer buying into them. But at least it is a way of investing in the future that creates jobs and opportunities and maybe we get to the emission reduction and congestion reduction we are looking for.

As an example, the ZEV Program, or Electric Vehicle Forecast, if we were to reach a 50 percent goal as I mentioned, that represents 500,000 cars a year that we would have to sell. We have a new shuttle transit program called Smart Shuttle Transit. It is demand based because we believe that the traditional transit programs will not achieve more than eight percent of the mode split from home to work. An alternative in areas that do not now have

transit could be this Smart Shuttle Transit opportunity using GPS and other technologies. Telecommunications may reach only eight percent in the view of some because of the conditions of work. This means home to work trips, not total types of trips. In the telecommunications arena, one of the areas we are looking at is teleshopping. As you know, most of the trips are not home to work, they are other than that and shopping is one of the them. Teleshopping may be an opportunity for our communities to get around the trip reduction program and a way to generate sales tax revenues to the local communities and not send it back to Lands End or other catalogue shopping programs.

ITS, as I mentioned, is a broad area. I do not want to get into much of the detail because you know them. Two other components of this plan is a marketing situation not just a technology situation. It is pricing strategy and land use strategy that must enter into the issue. The barriers we have to deal with include money barriers. From the electric vehicle standpoint we have infrastructure barriers. If you want to buy an electric vehicle today you could not charge it anywhere. We need something like 27,000 charging stations in the region to begin to serve the market. If you have a natural gas vehicle, we would need 5.000 fueling stations in the region to replicate what goes on with gasoline.

Naturally on Smart Shuttle Transit, we have to deal with a lot of externalities and pricing issues. ITS does not have the infrastructure available. If one of our shopping centers wanted to buy an ITS device or an AVI device, where do you buy it today? Could I use my credit cards on that AVI system? We do not have a fluid market for that situation. The goal of the task force was to say we need to get started on this issue now. We can not wait to the CARB mandate of 1998. We are setting the goal of 1996 to begin to see some deployment of these technologies to meet our air quality goals. You have all been talking about the downside of what happens in the technology arena. We can also evaluate the downside if we have sanctions put on the Los Angeles region and lose billions and billions of dollars every year for transportation funds. What kind of economic impact does that have on our society?

Electric vehicles have an opportunity and I am not going to get into the detail because there is a lot of debate on that. But I do want to jump to a couple of things that we were looking at. One is the need for us to reevaluate how we use our moneys. Does a local shopping center or activity center continue to invest in parking spaces or can it also invest in the technology arena so that we give that situation an opportunity to develop? Does it also use its funds in a more effective way? Can Reg 15, our carp001 funds, be used for technology uses such as those described here? This is not all going to happen by itself and we have concluded that the way to do it is through a public/private partnership, the very issue that we are here to talk about.

We have set up the Southern California Economic Partnership as a means to facilitate the process. What is key -- and let me jump to the bottom line here -- is that the partnership is made up of a Board of Directors of CEOs of the major industries, both public and private, in the region. The essential aspect to it is the industry cluster groups. EV, alternative fuel, Smart Shuttle and ITS, telecommunications, all representing the auto industry, the oil industries, the technology folks, and then supported with the financial community because you cannot install these things if you cannot finance them. We need the financial community to have a better understanding of what this is all about. Marketing communications is using the advertising and media in the region to help facilitate the process. Clean Cities, an extension of the DOE Program, which is virtually local government. We have these clusters beginning to develop today. We have public works directors, building directors and economic community directors all involved in coming together to figure out, especially in this arena, how we change the building codes, how we change the permitting process, how we change the land use process so we can actually bring these technologies to market. Included are business centers, shopping centers, activity centers, all of which need to figure out what is going on here so they have a way to buy these tools and we can begin to make it happen. Because without this process, nothing is going to happen by itself in our view.

It is a synergistic situation, and to go to the bottom line here, we believe that all of these elements must be in place for this type of program to succeed. Naturally, you have to have the technology, you have to address some pricing issues and you also you have to have the land use standards modified so it will accommodate the uses of these things. Without this, we are going to have a severe air quality problem, a severe congestion problem in the region and a severe economic problem that we cannot get out from under.

While this may be the Los Angeles picture, my view is that this is a picture that major cities across this country are going to be facing in years to come because it is not just unique to Los Angeles. We just happen to be on the forefront of it because of the extreme air quality condition we have in that region.

Our next speaker is Lee Munnich. Lee is with the Humphrey Institute at the University of Minnesota.

Discussant: Lee Munnich University of Minnesota

MR. MUNNICH: Thank you very much. I want to talk about a project that we have been involved with at the Humphrey Institute at the University of Minnesota for the Federal Highway Administration on ITS and the environment. The subtitle of the project is New Models for Cooperation in Advanced Transportation Technologies in Urban Areas.

This project entails three case studies in Houston, Texas; Minneapolis/St. Paul, Minnesota; and Portland, Oregon. A number of the participants in those case studies are in the room today, as well as some of our Steering Committee members who have helped shape the project. There is a paper in your packet which Dave Van Hattum and I wrote, which is the basis for this presentation.

Let me begin by defining new models for cooperation from our perspective. To us, this means ways of increasing understanding within and among three interdependent worlds -- the political world, institutions and citizens. Let me cut to the chase, in case I get cut off within ten minutes, and say what we think are the five components of new models for cooperation. First is aggressive stakeholder involvement, second is public outreach and education, third is coalition building both within and across sectors, fourth is integrating new technologies with existing projects and policies and fifth is built-in cost effectiveness analysis that considers least cost/full cost accounting and evaluation of strategic economic investments.

A number of the things that we say in our paper are themes that have crept up several times during the conference. In some ways, we may be simply reinforcing what people have been talking about. So what I would like to do is offer a framework or context. First, let me talk about three interdependent worlds. How many people in this room have ever run for public office?

Okay, good, thanks. A few of us have. My experience was about 20 years ago when I ran for the Minneapolis City Council. Working on this project has been a little bit of deja vu since I was elected because of involvement in my neighborhood in opposing a freeway. I moved on to other issues and the neighborhood moved on to other issues, but it was a good learning experience for me. As I have thought about the activities while I was on the City Council for two terms, the most political issues that I had to deal with had to do with transportation and traffic. Whether it was parking in a neighborhood or traffic through a neighborhood or the freeway, these were the most political of all issues. So when we start, we need to recognize that transportation is political, that everyone interfaces with the transportation system every day, and that there is no way of thinking about transportation without recognizing that. Those of us who work or have worked in the public sector know that the people who are elected to office shape the broad policies and directions for what we do, although they may not be there long enough to significantly affect the institutions that exist.

All of us have our own impressions of what politics means. For me politics is basically a marketplace where ideas and perceptions are translated into laws and budgets. Sometimes these are good decisions, sometimes they are bad decisions, but that is the reality, that is what happens. It is a big marketplace. The currency is votes - the votes you need to be elected, to pass laws and to make public investments. It might be useful to think about where the Congressional support for ITS investments and environmental policies comes from. In thinking about this, we need to recognize that they reflect several different and sometimes contradictory interests.

The first is jobs and economic development. When President Bush signed the ISTEA Act, even though it was a very far reaching piece of legislation, he basically characterized it as a jobs bill. Defense conversion has had a big impact on the current Administration's policy in terms of ITS technology, as well as global competition and progress in ITS in Europe and Japan. All of these relate to jobs and economic development, not transportation itself.

Second is environment and sustainability. This has moved from a peripheral concern to a mainstream political issue over the last 10 to 20 years. It is driven by "not in my back yard." Baby boomers such as Vice

President Gore have made it a major political issue. But the real group that is having an impact here is Generation X. I have been reading a lot about Generation X because I have three of them and then one in Generation Y. I also work with a lot of these people at the Humphrey Institute and I have learned about things like "boomeranging," which is kids coming back home, and "down nesting" which is baby boomers moving into smaller houses so their kids can't boomerang.

The one thing about Generation X is that they are very committed to environmental issues. I see this at the Humphrey Institute. Dave Van Hattum is one of those, people who believe in environmental issues above many others. This is important because this is a generation that is emerging, that is coming up into leadership roles, and they put environmental issues above many other things. These issues are still being clarified and there are a lot of conflicts that need to be worked out, but this is important in the political sphere.

The third issue is economic polarization. My Member of Congress is Martin Sabo, who is on the Transportation Appropriations Committee. I have never heard him give a talk to his constituents about transportation, but I have heard him talk about economic polarization. He is an urban Member of Congress who is concerned about the economic, social and geographic polarization that is occurring in Minneapolis versus the suburbs and he is interested in these kinds of policies. We need to think about how transportation policies relate to that. That is one of the reasons why we helped fund Lisa Saunders and Sam Myer's work on looking at these equity issues. There has not been much work, as people have talked about, in this whole area. We need to do more of it.

A fourth area is community involvement. I mentioned the neighborhood movement, that I started with, helped get me elected. The movement has matured significantly, to the extent where neighborhoods and community groups are now replacing the traditional political parties in terms of their political force. So as a context, we need to recognize the political arena that is going to shape a lot of what we do.

The second area is institutional, and we talk a lot about that. Let me just say that ISTEA has some very powerful long-term institutional effects. One is decentralization in decision making. A second is cooperation across institutional boundaries, and a third is citizen involvement. It is in the law. Whether it is being followed fully is what needs to be debated. I do not think the direction is going to change but will continue in the future. Institutional concerns include the capacity of state DOTs and environmental agencies to model travel behavior and to assess the environmental, land use, economic and social impacts of transportation policies and ITS applications. I am not sure that the capacity is there, and we need to think seriously about how it is going to be developed.

Second is the capacity of MPOs to apply comprehensive regional approaches in setting transportation priorities. The MPOs are a critical element as we try to move forward in this area, and we need to address how to increase that capacity.

The third is the capacity of environmental and community groups to understand and effectively communicate how their concerns relate to transportation and the application of policies.

The final word is that of citizens. We need to recognize that citizens are customers who are concerned about mobility but also about the long-run environment.

I have one minute left, so I am going to talk quickly about some models that are important. One is to ensure broad stakeholder involvement at early stages of planning through policy consultations. A good model for stakeholder involvement is the Surface Transportation Policy Project. We should look at how to replicate STPP on a regional basis.

The second is building coalitions among key stakeholders. There is an excellent paper that Hank Dittmar did for a congestion pricing conference about a year ago. It talks about the way the San Francisco area built its coalition of businesses, transportation, and the environmental community. Thank you.

MS. JEFF: Our next speaker is Hank Dittmar, the Executive Director of the Surface Transportation Policy Project.

Discussant: Hank Dittmar Surface Transportation Policy Project

MR. DITTMAR: I want to do a little more question asking myself. I hope that this session can be one where we have some discussion. So maybe in approaching this question of cooperation and institutional challenges, I will put some questions on the table and hopefully we can learn from one another about it.

I do approach this question from the standpoint that a public/private partnership is more than just the federal government and large corporations working together to develop technology. That a public/private partnership is, as Mr. Cox pointed out, something that builds up from the local level and that involves local business people and local government people working with public interest groups in their community to try and understand and fit together what makes sense locally. The key to deployment of ITS and ITS technologies is putting all that together. In the San Francisco Bay Area when we approached the very difficult question of congestion pricing during the peak hour on the Bay Bridge, which began by bringing the business community and the environmental community and the local government and transit interests together. We thought we could deal with these implementation issues related to people of color, social equity, and the inner city communities by working through the elected officials. We discovered that that was not the way to do it and that that coalition had to be broadened greatly in order to deal with questions like pricing.

As you think about partnership, yes you want business involved, you want the suppliers involved, but you also want the people that have to carry their freight or bring their people to work involved and you want people who will be affected by the challenges at the table. The institutions have to go beyond the first blush and we learned that from making some mistakes in the Bay Area.

Some questions: The first three or four questions have to do with technology assessment and evaluation, evaluation of intelligent transportation system technologies. Can an organization that is charged with technology development and research and development serve at the same time in a technology evaluation role? Can an organization composed of industries who are looking to create markets be expected to perform the difficult tasks of looking at the social and environmental and economic implications of that development for local communities? Can an agency charged with promoting a federal highway system be expected to act as an impartial evaluator of the technology to be used in operating or enhancing the efficiency of that system? Can states and MPOs be expected to buy this technology absent evidence of independent evaluation? Will social equity advocates and environmentalists believe ITS AMERICA or the Federal Highway Administration when these technologies are claimed to be benign or beneficial?

I would suggest that we need to think carefully within ITS AMERICA and within government about the need for bringing other communities in and together devising some institutional mechanisms to provide that kind of assurance of technology evaluation. That is why we developed in the Congress an Office of Technology Assessment.

Some deployment issues have to do with different owners and operators of the system. I think that the key issues for ITS AMERICA are, in fact, the institutional issues and the deployment issues. You heard a couple of different visions from Hal Kassoff and from Chairman Cox. This is where the difficult questions are going to come together. At the metropolitan level, at the regional level and indeed within a whole state, you have a situation where in many states a state owns the highway system, the limited capacity system, but cities and counties own local roads. You cannot say that localities are optional because whatever you do on the highway system has impact on local streets. If you are bringing a lot more cars into the downtown, they have to get off that system and store themselves somewhere and people are concerned if they are going to be stored on people's local residential streets. Transit authorities need to be brought into the picture. Within this context then, you need to look for an institution that can manage a multimodal system that does not do so from the standpoint of being biased for one system that they own or another system that they own. I have believed that the ways of beginning to deal with that are embodied in ISTEA in the metropolitan transportation system requirements of ISTEA: in the state within the inter-modal management system and the process for developing inter-modal management systems. So, the systems context and an organizational framework for dealing with systems are both important.

Now for some deployment questions: How are we going to deal with NEPA with respect to ITS technology? The National Environmental Policy Act is critical and clearly some of these technologies, even though they do not cause physical disruption may cause social and environmental changes that we need to examine. We need to begin thinking about modeling and dealing with environmental assessments of ITS technology. To do so, we need to think about whether we are going to include these technologies as part of highway projects or we are going to pull them out of highway projects. Very difficult, and that is a philosophical question for MPOs and states to deal with. If you are going to do traffic operation systems as part of all your highway widening, then is that a part of the system? If so, how do you evaluate the cumulative impact of a Traffic Operations System on an entire system. So that is a question we need to answer.

What about project review and approval and conformity review for air quality? Do we have the models, do we have the techniques to model the impact of these things? These are all institutional questions that research needs to examine.

The second question on deployment is how are we going to pay for the framework that the public sector has to buy for these systems? This is a big challenge for everybody, an area where the environmental community and ITS AMERICA have some common ground. We want to be able to have the MPOs and the states institute these improvements as a part of their normal planning process. If we fail to institutionalize the funding, there will be growing pressure from the technologists to continue the earmarking of these projects in the Congressional process There is a common ground in reaching out to the MPOs and the states to talk about how to bring these things into the normal process, to avoid the spotty earmarking that is likely to cause a negative backlash onto this whole movement.

The final set of questions: Is there a role in the development of ITS for the environmental community? Apart from all these issues about how you belong to ITS AMERICA or what you do about membership, the more meaningful question, because ITS AMERICA is such a big organization with so many committees, you could even put environmentalists on the board, but meaningful involvement is probably something different. This may involve thinking differently about the role of the technical committees and the role of committees that deal with societal implications. One question I would ask is if we are dealing with social implications and environmental implications in a committee over here, and the technologies are being developed over here, where do we bring them together? If we do not bring them together, it is difficult.

Secondly, can we agree to work together on specific projects that can show an environmentally friendly market for these technologies? I would submit that we can. We are doing research on public attitudes towards transportation use. You need to do that in terms of customer development. Advanced public transportation systems, environmental groups and local agencies in Boulder have come together on a very advanced public transportation management system. The Bay Area Congestion Pricing Study is one where the environmental community has been involved from the outset. We can work together, and perhaps including us in some of your research might be an approach.

Finally, I guess I would just have to respond a little bit to Hal Kassoff's comment about jackknifed tractor trailers. I spent a lot of time developing incident management systems in the Bay Area and I too have a hard time understanding how environmentalists would be concerned about removing damaged vehicles from the freeways. There is a wide range between jackknifed tractor trailers and a totally automated highway system. Somewhere in the middle of that wide range of activities; from building an automated highway system to a new physical infrastructure, a set of technologies begins to move us toward greater dependence on the automobile. The tradeoff and the balance between that is a legitimate area for discussion. It is important that we understand we are dealing with a balancing of interests and not a "yes or a no" question.

MS. JEFF: Our next speaker this morning is Cynthia Burbank. Cindy is the Chief of the Environmental Analysis Division of Federal Highways. She has the dubious distinction of being Federal Highway's reigning expert on all issues related to the environment, most of which is air quality. I for one would like to sit at her feet and learn from her font of wisdom and also figure out how she does all of that plus deal with wetlands, endangered species, landscaping, water runoff and noise.

Discussant: Cynthia Burbank Chief, Environmental Programs Division, Office of Environment and Planning, FHWA

MS. BURBANK: Much obviously has been done and is being done to build a public/private partnership in the ITS or ITS area. But most of that has been along a transportation axis. We do need to focus a lot more of our energy and our attention on building that partnership along a transportation and environment axis. I particularly liked Monty Hempel's bulls-eye a little while ago which showed a series of circles. Within the center of that circle, there is an institutional relationship between the transportation entities, the DOTs and the MPOs, ITS AMERICA, the private sector. But outside that was the environmental advocacy community. Beyond that was the interested public and beyond that the general public. We clearly have to either narrow those circles down or somehow build connections between them.

Let me start by focusing particularly upon the need to do that along the transportation institutions and the environmental advocacy institutions. Why? As Monty said so eloquently, because the environmental advocates are here to stay in transportation. They are well organized. As John Kessler said, they are smart and capable. They have strong motivation and they are here to stay because they represent a growing set of values and concerns in the interested public and even the general public at the furthest reaches of that bulls-eye graphic.

I have seen a number of surveys that show that this environmental concern cuts across all classes and educational levels. It is not an elitist set of values. In fact, one survey showed that over 80 percent of Americans consider protecting the environment to be more important than keeping prices down. I say that with some caveats about the validity of surveys, but nonetheless it is a pretty strong indicator.

Another reason that we need to build a model of institutional cooperation between the transportation and environmental organizations is that we in transportation do need to be challenged and infused by concerns about both ecological and social human equity impacts of transportation. We in transportation have made a wonderful contribution in this country, but there is much more that we can do to make the contribution in the social, the human, the equity area and the ecological area. We need to begin to shape our transportation facilities and our programs to serve communities' quality of life as well as we have done in serving mobility and the economy.

Well, let me go from this to making some observations about how we should embark upon building this cooperation. First, and perhaps the most important point is we are going to have to face the need to devote more of our time, our emphasis, our resources to building those connections. We may have to cut back on some of the more technical areas in order to spend the time building those connections. We need to do it at all levels, from the policy setting, the vision setting, the research, the operational tests. We need at all of those levels to build linkages between the transportation and environmental organizations and constituencies.

We need to begin by focusing, as we started out in this conference, on the visions, the vision setting, and the values that underlie our different goals. We are still pretty weak in this area on trying to come together on what our vision is and our values are. We have tended to see too much conflict between the traditional transportation goals and the environmental goals and that we can find a much bigger area of congruence between the two of them if we talk together about what our vision and values are.

In doing so, I would caution that we not focus too much on the air quality impacts and aspects of ITS or ITS. We have tended to overemphasize this, perhaps because the Clean Air Act tends to impel us to focus on them. I am increasingly convinced that in many areas we can meet the air quality goals and standards through clean cars and clean fuels and effective emissions I/M programs--without having to grapple with some of the basic concerns that the environmental community has brought to transportation about increased auto use--concerns like the nature of our communities, equity issues, habitat fragmentation, and other ecological impacts.

Finally, in meeting these concerns, we need to find ways to stretch to the outer ring of that bulls-eye graphic to involve the public, because ultimately the values that we are grappling with and the different visions that we have are not ours alone. We are trying to affect the behavior of the average citizen out there, and we will affect people's travel behavior, depending on the choices that we make. We need to focus jointly upon new and better forms of public involvement. I want once again to pick up on something that Monty Hempel mentioned, because I intended to bring it up, also. One of the new forms of public involvement is this "deliberative opinion poll" that Monty referred to earlier. It was written up in the Washington Post on Sunday, a lengthy Op Ed article about how this technique has been used for the first time in Britain, and how it can be a tool to educate and inform a group of the public and then test what their views and values are. I would challenge the environmental groups and ITS AMERICA to work with us in FHWA to figure out if we could do something like this and get a cross section of the American public to invest three days in the effort. Three days is what they did in Britain anyway. This approach is partly an educational process as well as a probing process about what people's values are and the different policies that are desired.

MS. JEFF: Our final speaker is Chris Body.

Discussant: Chris Body ITS AMERICA

MR. BODY: I do not know how many of you were at last year's ITS AMERICA meeting here in Washington, but if you remember, Secretary Pena's speech was interrupted by a fire alarm. At this year's annual meeting in Atlanta, Secretary Pena gave a resounding support of ITS technology. So I am fully confident that when we have an environmental conference next year, Hank will be here giving resounding support for ITS technologies. As you look at this panel, I am not sure if you realize how we organized it. We tried to start at the local level and then move on to the regional level and then talk a little bit, Cynthia and I, about some of the national and international cooperative partnerships on which we have been working.

What is ITS AMERICA? It is a public/private partnership that is truly unique in its mission. We are working diligently to bring to the table all the stakeholders concerned with ITS. I agree with what many of the people have said, that we need to reach out to that outer ring and get the general public involved.

I was encouraged by John Kessler's remarks, and I interpreted them to mean that EPA will have a more substantial involvement with ITS . We also need to reach out to DOE and the Department of Commerce and get their involvement from a federal level.

A current effort within ITS AMERICA is identifying some of our early winners. Many of those early winners will be technology oriented, such as the Travtek Project that you saw in the video I showed yesterday, some of the commercial vehicle operation projects from a technology standpoint and some of the public transit projects. We also need to focus on some of the institutional arrangements that have been developed such as Hal's I-95 Corridor Coalition that is coordinating ITS on a regional scale, as opposed to just a local scale.

The genesis of the ITS Program was more of a reactive state, as we finally realized that we could not just build our way of congestion any more. We needed to take a step back and analyze the system and consider how we can get ahead of, at least try to get ahead of, the game. To that end, one of the things we are working hard to do within ITS AMERICA is to be proactive and get all the stakeholder groups involved up front. We need to reach a balance between testing the new technology and analyzing the institutional arrangements. We have realized over the last 20 years that highway and transportation projects cannot be steamrolled through the system. There needs to be consensus at the local level before the process takes place.

Realizing all the different technology firms and the non-traditional transportation organizations that are becoming involved in ITS, we need to help them understand what the planning processes are, what the TIP, SIP and NEPA processes are. It is important to help our private sector members understand where the environmental groups are coming from regarding including environmental assessments, up front in the planing process. I do not think any of us wants to get five to ten years down the road to deploy these systems, and we realize we cannot because they have very negative impacts on the environment or their impacts are unknown. There is the chance that they will not meet the Clean Air Act requirements, or from a public transportation perspective will not meet the needs of the Americans with Disabilities Act.

One of the excellent statements that Denny made yesterday was that all the deployment is local. One of the things ITS AMERICA is doing is developing regional chapters of ITS that help to reach consensus at the local level. We have about four or five that are currently official ITS AMERICA Chapters. We are also working with about 15 to 20 others that are interested in developing local programs. We are also working with many universities to develop student chapters because the students in our colleges today are going to be the ITS officials and experts of tomorrow. Many of you will go back to your region today since most of you have a full-time job besides attending these conferences. It is hoped that what we can do at the national level is help to keep you more informed, which will enable you to make more informed decisions.

What we are working to do with the regional chapters is replicating our national chapter and getting all the stakeholders involved. Part of the official sanctioning of a local chapter is to ensure that they have all the necessary transportation stakeholders involved. We need to broaden that requirement to ensure that they include all other possible consumer advocacy groups, environmental advocacy groups, all the public transit agencies, etc.

Finally, I would like to talk about some of the current models that we have been developed already, which include the development of standards. For example, the Houston Metropolitan Transit Agency saw a specific need to link all its "black boxes" together on its buses. Instead of procuring seven or eight different components, which may or may not communicate with each other, it took a step back and looked at it from a systems perspective. They brought the private sector in after analyzing its needs and developed a standard that is now sanctioned by the SAE and fully accepted by the private and the public sectors. This can only happen if needs are identified up front.

We are also in the process of identifying some electronic toll and traffic management, some AVI standards. To that end, we brought in the public and the private sectors and academia to discuss different issues associated with where they want to go regarding those issues.

We also need to keep our outreach effort going with local cities and with public transit agencies. We are in a substantial effort to bring in public transit agencies. We increased our membership in that area about 100 percent last year that was a pretty substantial undertaking. We are working hard to understand how we can use some of the defense conversion money to bring in our national labs. JPL is currently working with the architecture teams, which brings us to another model of cooperation: the architecture consensus process that is truly an open process. We just had about 10 regional forums around the United States and we are doing the same thing with the National Program Plan. The Plan was developed concurrently with ITS AMERICA membership and DOT to gain consensus as to what ITS deployment should look like. That is a living document that will change over the years depending on the involvement of different stakeholder groups.

One of the unique things we are doing at the international is planning a series of World Congresses on advanced technologies. You can imagine those interesting planning meetings we have. Considering the meeting is being held in Paris and hosted by the French, the Chairman of the Board is from the United Kingdom, and we are also getting input from the Japanese and North Americans.

It is important that we consider some things that Stephen Covey brought out in his book, "The Seven Habits of Highly Effective People." When we go to a meeting where there are going to be negotiations, we need to go there with a win/win attitude. We need to believe that we are not going to win at someone else's loss.

Another one of the habits is to seek first to understand and then to be understood. It is very important to walk a mile in someone's shoes to understand their needs and value system before we criticize some of their goals. If we keep those two things in mind, we can work together at the local, regional, national and hopefully international levels to advance the deployment of ITS technologies on a global scale. Thank you.

QUESTION AND ANSWER SESSION

MS. JEFF: After having all of our speakers race through their presentations, we have managed to allow ourselves about 20 minutes for questions.

DR. HORAN: I am so used to making announcements, I forgot I can ask questions. We have several breakout groups that are dealing with various issues. One is dealing with institutional issues and they are going to have to grapple with given limited time and resources what kind of institutional gap or what institutional dynamic is awry which over the next five years would most warrant attention. There is a lot and this panel has covered many. I was wondering if the panel could in some way help that group by commenting upon which, given the host of things that we have just heard about, would they prioritize as something that requires relatively immediate attention.

MS. JEFF: You each have 30 seconds.

MR. KASSOFF: Speaking on behalf of state transportation agencies, the first is at a very, very basic level and that is convincing transportation agencies to shift their way of thinking about their system from one of a passive attitude to one of a proactive intervention attitude. Civil engineers in general, transportation people in particular except for deploying traffic signals or fixing potholes have taken a very benign view of their work and have not been interventionists. So the number one obstacle is to become involved.

Beyond that, we need to organize the thinking at a conference such as this into arrays of immediate and obvious things that can be done that there would be general acclamation about the benefits and no real necessity for huge public debate. I heard Hank say clearing tractor trailers off highways is in that category. I will certainly concede to him that if his concern is down the road a piece, we are talking about truly automated highways and doubling or tripling the vehicle cart-ying capacity of the lanes we have, those are legitimate areas for debate, for discussion, for social issues and policy issues at the highest level.

But in between is a vast array of obvious things that need to be done such as communicating with our customers, such as making them more intelligent, such as coping with non-recurring incidents that make the system dysfunctional, which I would argue need to be done in the next five years if ITS is to succeed and should not be the kinds of issues that are subjected to environmental impact statements and NEPA as would the legitimate system changing formulations such as truly automated highways.

MR. COX: A couple of comments. I would say that the environmental and social issues, and safety issues, are certainly important to track. I tend to find from companies that comment about this issue all the time, if government would just get out of the way, maybe we could bring these products to market. We have uncovered a lot of barriers to implementation as we have evaluated advanced transportation technologies. So that is an issue that has to be dealt with from a local and state government standpoint.

The other part of it seems to be standardization. It was mentioned earlier in these conferences, we have people today out there that would love to be able to put in an AVI system, who would love to be able to use their credit cards on their AVI systems that we all carry around in our pockets, but for some reason we are not able to do that yet. Addressing the consumer's way of functioning is what is important. We tend to look at these things too institutional sometimes and not look at the consumer market as the way it actually operates out there and has a better understanding of that.

MR. MLJNNICH: One of the major things that could be done is to focus on enhancing the role of MPOs. That is already there in terms of ISTEA legislation, but more needs to be done in terms of what is the capacity and what are they doing in terms of broadening the perspectives to a more comprehensive approach as far as transportation and how does ITS fit into that.

give as an example is the Portland Metro area that has a 50 year strategic plan. Their first objective is land use policy and everything else, including ITS, are planned to fit land use policy. There needs to be a more focused effort on what is the role of MPOs in this whole effort.

MR. DITTMAR: I would agree with Hal's comment about shifting from an era where our response to problems with the system is to build capacity, which is essentially a passive response, and the need to move toward an active approach to operating and managing the system. To do that, the biggest challenges or one of the big challenges is to understand that we have a freight and passenger system. a multimodal system and that many different entities own and operate, private and public entities own and operate that system. So, ITS is the technology that gives us the opportunity for knitting those disparate components together. But breaking down the ownership and operation and private and public barriers to get to realize the information possibilities of that technology is profound. The technology can be used to optimize the system rather than simplistically -- you know, meet a variety of social objectives rather than to simply maximize vehicle use.

MS. BURBANK: I want to echo Lee's comment and say that the biggest challenge is to strengthen MPOs so that they can serve as an effective metropolitan regional forum for building a consensus, for bringing the stakeholders together, and the public education and public involvement in order to have a consensus at that level.

MR. BODY: One of the most important things to do at the local level is help the local public transit agencies and the local DOTs understand what true intermodalism is. If you look at somewhere like Houston Metro where they understand what intermodalism is because everything under one roof, and you look at some other localities where they are still talking about disparate modes of transportation, that is not what ISTEA implores you to do. It wants you to look at a seamless system of transportation. When we look at providing information, that information needs to be seamless also. Whether you decide to drive your car in the morning, to drive to the park and ride lot, or to take public transit right from your home, it needs to be a totally intermodal and seamless system.

MR. ROUDEBUSH: I enjoyed Monty's suggestion of tweenies, but every time I have an opportunity to be a tweakie, it is sometimes useful.

About 20 years ago, we passed the National Environmental Policy Act that was written to perform environmental impact statements based upon finding out how our actions in the federal government influenced our human environment. The discussion this morning has been a checking and relooking at what was meant by that act 20 years ago. I said yesterday we make plans and 20 years from then we find out whether they were good ones. My question has, as ITS is now spending lots of federal money, has anyone done an EIS for that action? I say that because the environmental review process is exactly the cooperation technique that is mandated under that act that is one of the most constructive things that can happen. We have been talking about how to make it happen in a positive direction.

MS. JEFF: I guess I will pose it to Cindy first and then I will come pick on Hal.

MS. BURBANK: Well, Gloria, when you said I dealt with all environmental areas there was one exception, and that is the whole EIS and NEPA process. It is another division. Certainly if we have not been doing environmental assessments or EISs for ITS activities, it is time to start doing some kinds of assessments, especially for those activities that are going to have significant impacts and are large scale.

MS. JEFF: To be fair to Cindy, and let me take off my moderator hat for a second and put on my Federal Highway hat, one of the critical elements is that the Environmental Protection Act was focused at the project level. Members of the panehave made a very critical point that the issue of looking at it from a systematic standpoint, and that is stepping back before you get to the individual project levels. That is one of the things that we have talked about here today and have talked about as we begin to look at the Intelligent Vehicle-Highway System. How does it fit into the whole concept of a transport system and its delivering its products in a host of different ways to all of its users? That that becomes more fundamental.

The Environmental Protection Act is doing a very good job of dealing with individual projects. The question of looking at it systematically, ISTEA has given us some mechanisms to do that with and we need to progress with the opportunity to utilize some new techniques to accomplish the fundamental look at what is, why is and who gets impacted. Hal still gets a chance.

MR. KASSOFF: I am going to answer this as someone whose professional career grew up in the year of the National Environmental Policy Act. I am an advocate of it. If the option was here to do away with it, I would think it was a terrible mistake. It has done a lot of good in terms of opening up the eyes of advocates of various actions as to what the consequences of those actions might mean.

Having said that, the notion of an EIS for ITS is patently absurd on the surface because there is no such thing as ITS as a single action with single impacts. Now if the City of Los Angeles was proposing an automated highway system that could double or triple the amount of vehicle miles of travel in a year, I would say absolutely yes. That is a major action with major environmental consequences.

This year our state highway administration will deploy 200 devices to sense the speed of vehicles on the system and about two dozen television cameras so we can view what is happening on the system at critical interchanges and another dozen or so variable message signs, which nine times out of 10 get the right message on at the right time. Should those actions be subjected to a full EIS process? I ask you.

MR. ROUDEBUSH: If you are telling us that all of these actions are positive, then you should shout it loudly.

MR. KASSOFF: I am shouting it loudly on the face of it and if I have to spend six months and pay a consultant to do it, we are going to bog this process down in unnecessary bureaucracy. What we have to do is distinguish what we mean by ITS and it will be ITS and it should be ITS. As a member of the ITS AMERICA Board, I will be supporting that change.

ITS in this generation today, state of the art, is not about changing land use as has been discussed. It is not about changing our life styles. In this generation for the next five years, it is just about being aware about what is happening on our system, being able to understand it ourselves, act accordingly and relay that information to our customers so they can make intelligent choices.

Now, on the horizon clearly there are some implications. But let me throw another one to you that is a little trickier. Automatic toll collection, now that is in the gray zone because that does improve the traffic carrying capacity because in some places the toll plaza is a meter that restrains the movement of traffic. Should that be subjected to EIS? That is a tougher one.

MS. JEFF: Before we try to answer that question, I am going to let Hank jump in. You have an excellent question, but I have people standing at mikes and clearly we have some interest here.

MR. DITTMAR: Hal begins to sketch some kind of framework there and I guess I would say that the problem is not a simple one of doing an EIS on this whole range of possible technologies. But it does raise difficult questions and that is why I raised NEPA. Automatic toll collection may clearly have some localized environmental impacts related to cars idling. Ramp metering might mean that you put the cameras on and you put the sensors in the road, and the next step to a traffic operation system may be to put ramp meters on the freeway. That will have impacts in terms of cars queuing at the ramps that may have air quality impacts. It may have impacts in terms of diverting traffic onto local streets. So how do you deal with that? Well fortunately NEPA says we do an environmental assessment and we decide whether this is likely to require an EIS. That gives us a framework for dealing with some of these questions.

My concern is that we sketch out those steps and that is what Hal has been trying to say, because otherwise we may tend to get ourselves into some very difficult problems with segmentation and things like that where you put portions of ITS on some part of a system without an environmental assessment and then, as you move to build

it, you have in a cumulative sense made a major impact on system capacity. So, it just requires some thinking through, and it is thinking through that does not happen at the ITS AMERICA table except in the sense that ITS AMERICA thinks about deployment, not in the sense of technology development.

MR. ROUDEBUSH: May I say that you are reflecting what Barbara Richardson said and when you start talking about it early, it is great and if you let it get into legislation, it gradually goes to litigation. We did not talk about this 20 years ago, it is time we start right now because you should not be afraid that an EIS is going to do damage. It is written in there to do good.

MS. JEFF: Thank you Peter. Whoever is in Peter's breakout group, you are going to have a lively discussion. Let me go over here since I started there.

PARTICIPANT: In listening to the conversation this morning I have heard a number of common themes about expanding the range of stakeholders that get involved in the table, the range of values that are considered in the discussions, the development of institutions that help to make that table something that can actually create decisions and the desire to have the expanded set of stakeholders look for win/win solutions that get people to understand each other's points of view. It seems to me that all of that is highly desirable, in fact overdue.

But, we have shortchanged two issues, one of which was dealt with just now that are on the cost side of doing all of that. One of them is time and the interchange between Peter and Hal just illustrated some of the concerns and the tradeoffs that are developed between thoughtful consideration, thoughtful political discussion and time. The second one I have not heard mentioned in this panel is cost. Almost always win/win solutions that accommodate a wide range of interests mean that there has to be a set of policy accommodations that cost a good deal of money.

In the Boston area, where I come from, we have seen a grand coalition develop a massive project, the Central Artery Third Harbor Tunnel, in which fitfully and not entirely peacefully environmental interests and transportation interests have developed a compromise that they can live with. Bt the result of it have been a ballooning bottom line for the project. As we talk about ways of accommodating this in ITS, we have to face the fact that there are cost implications to these kinds of relationships.

PARTICIPANT: It was probably a pedantic statement. The question is how do you think about building cost into the considerations of broad stakeholder participation and development of win/win solutions?

MR. DITTMAR: I found in my years of doing project development in California that it cost less to bring people in at the early stages than it did to have the project delayed by citizen opposition or lawsuits for many years, because the escalation of costs from project delays more than eats up the cost of paying people overtime to go to meetings at night when they are not working and stuff like that.

MR. KASSOFF: Just a quick addition. Again, going off ITS and into traditional transportation thinking: on one end of the spectrum a new freeway. at the other end, fixing a pothole--we typically do not spend a lot of time doing cost benefit on the pothole. Obviously we not only need to do cost considerations but environmental on the freeway.

We have to think of ITS in the same way. The value of our consumers' time is such an overwhelming factor in any cost benefit evaluation that giving out accurate information to people so they can make choices is almost as obvious as fixing a pothole. On the other hand, investing in an enormous way in making the whole system automated and electronic that is decades away in terms of even the engineering feasibility, much less the institutional, clearly deserves a very thoughtful debate, a careful cost assessment and environmental assessment as well.

MS. JEFF: Let me just jump in and respond in just one piece or try to frame something from what you said. One of the things I found interesting in your categorization was the whole issue of the additional costs being necessary because you have a host of folks involved in your input activity. I do not take as a given that, because we have a large number of individuals involved in the discussion about what it will be, everyone in that process has

to be able to identify their pot of money. Rather, that we have come to a solution as a result of a synthesis of all of those various inputs being involved in the process that provides an answer that is the best answer as opposed to simply one that was made because this group was bought off or because I gave them X amount of money and I bought off that group by giving them Y amount of money. I do not know of any activity in the transportation business where we can all say that we have identified the pot of money it takes to buy off a group to agree with the project because there are some groups for which no amount of money is going to be available to buy off.

PARTICIPANT: I would not put it quite that starkly and I do not think it is a question of pots of money to buy off groups, but it is the case that as you take account of more values and more goals and try to find accommodations that optimize among them. It is likely the one way you accommodate them is increasing the cost of the project. Hank's point is well taken that it is probably better to do it up front than behind. I am certainly not arguing against involving the stakeholders. All I am saying is that there is likely, in our current economic climate, to be strict limits on the amount of money available for investment in all of these areas and we have to be quite explicit about what we are doing with a finite pool of resources if we think of these broad coalitions of interest that are accommodated in the process.

MS. KANNINEN: A comment or a question that some of the panelists raised and a question that I have heard throughout this conference in different types of discussions is, "How can we bring the general public into this discussion, this arena and how can we get more environmental groups involved and why are environmental groups not willing to devote their resources to ITS?

I would like to suggest that the burden of proof that ITS is something that people, and especially environmental groups should be interested in, is on the ITS community. I do not think that it is been effectively proven at this conference or anywhere else that I have seen in papers that ITS actually can have environmental benefits. We have heard several vagaries about things like ITS can promote congestion pricing, but we have no evidence that congestion pricing might ever be implemented in our own life times. Another example that is often used is ITS can help public transit. Anyone who has looked at travel behavior studies and modal shares and things like that knows that transit ridership is very low in most cities. We are talking about tripling or quadrupling transit ridership if we are going to have any kind of environmental benefits out of ITS and its use in public transit.

I would just suggest that if you want to get people interested in ITS, you have to prove that there are benefits. We need to see some real quantitative studies that are going to show that some of these technologies are indeed going to decrease VMTs or whatever it is we are trying to decrease and actually provide environmental benefit.

MR. COX: I might suggest from a different perspective that most people rise to an issue when it is at the project level. That happens at the local city level. On one side of town, they could not care less about what is going on at the other side of town because it does not affect their back yard. That is the case here too. ITS devices, whatever they may be, appear to be tools that can be used in the transportation system at some point, at some place and I would hope that we at least create a standard where they could be allowed, but it is one that are actually going to be used. A city is going to have to decide whether they want to price parking, whether they want to price congestion pricing, whether they want to price anything or what kind of traffic signalization system they are ultimately going to use. The public will be intimately involved in that decision once it reaches that level. But we are sitting at a stage today where if I wanted to use an AVI device, I do not have that choice available to me yet and that is what this ITS AMERICA Program should be about is how we can develop standards so there can be choices for the public to use.

MR. ROGERS: My name is Bill Rogers from the Center for Neighborhood Technology in Chicago. My question is for Mr. Body or anyone else who cares to respond. You mentioned your increasing success in involving transit agencies into the ITS AMERICA organization. I wanted to ask you how many railroads, freight railroads are members, how many ports are members, is Amtrak a member and are the transit agencies having an active role in the design of system architecture and other activities?

MR. BODY: Why don't address your first point? One of the things we did develop over the last year is an Intermodalism Committee and what they are dedicated to doing is involving the shippers, more so than just the CVO Committee which is more oriented towards truckers. But the intermodalism committee is looking at involving the shippers and the railroad. We have been talking with the Federal Railroad Administration about becoming involved in the program also.

Regarding public transit agencies, we have been working hard also to have the public transit agencies involved in the architecture consensus building process. I do not know the exact numbers, but at each of the regional meetings we had a number of public transit advocates within the program. We have been promoting ITS to the public transit community. Believe me, it is a substantial outreach effort to help them change their thinking. I mentioned earlier about the mindset of single mode and that is how they think. They have their every day operations. They do not have the time to think about all these different advanced technologies. What we need to do is prove to them how easy it is to implement these technologies and what the true benefits are.

MR. ROGERS: How about the freight railroads, the ports, Amtrak?

MR. BODY: Part of intermodalism is do help us bring in those groups.

MR. ROGERS: There are no current members?

MR. BODY: I would have to check our membership list. I am not sure.

MS. JEFF: Let me try, in closing, to bring some thoughts that I heard fairly consistently across the board from our panelists. In looking at models of cooperation there are a host of levels at which one can do it. The most essential element, regardless of level, regardless of structure, regardless of whether or not we are looking at a system or an individual project, is the whole issue of getting those who use the system, or are impacted by the system, involved in that decision at as early a stage as possible.

I have heard discussion about middle grounds between whether to let incidences go unmanaged so that you reduce the amount of travel taking place. Do we have any environmental benefits from fully automated highways that significantly increase the lane carrying capacity of individual highways? I have heard others talk about getting government out of the way and letting the private sector bring the technology to market.

But, the one thing that I also consistently heard was to find ways to take an entity like the Metropolitan Planning Organization, enhance its role as the forum for stakeholders to do the conversations about how transportation works. One thing that Hal wanted to say and did not get a chance to say is, that as much as we would like to, Intelligent Vehicle-Highway Systems, Intelligent Transportation Systems in and of themselves are not the answer to our environmental problems, be they air quality or noise or land use. They are simply one of a host of tools that help us resolve those sets of issues. As we look at ways for folks to work together, it is working together to make this one tool as effective as it can be in its contribution to addressing how do we manage the balancing act between a solid effective transport system and one that is in the broadest sense of the word environmentally balanced. So, we are not only concerned with noise and air and water, but with the human beings and the impact that these systems have on the way they live, on the opportunities that they have and on the overall quality of life that they are some day able to obtain or not obtain by the decisions we make with respect to a transport system.

If we leave from this session with nothing else, it should be with an appreciation for the essential elements of a successful model are these. First, have the stakeholders involved from the very inception. Second, establishment of vision and goals is important. Finally, as you work through the process, recognize that all of these are simply one of a host of other tools necessary to address how we effectively move people and goods.

LUNCHEON PRESENTATIONS

MR. BURWELL: I am David Burwell from the Rails-to-Trails Conservancy. We have two speakers today from U.S. DOT, both who are very involved with ITS policy, Gloria Jeff and Grace Crunican. Ms. Jeff is the Associate Administrator for Policy for the Federal Highway Administration. She is sitting in for Jane Garvey our Deputy Administrator today. Since Gloria has already spoken here today, I was not going to say too much about her credentials, but I was told that folks do not know exactly her background. It is such an impressive resume that I would like to share it with you.

Gloria Jeff is a graduate of the University of Michigan with a Bachelor's and a Master's in Engineering. She is a civil engineer. She also has a Master's in Urban Planning from the University of Michigan. Before being the Associate Administrator for Policy at FHWA, she was the Deputy Director for Planning at the Michigan Department of Transportation, and also I believe she was head of the Planning Committee for ASHTO.

Among her honors and awards, there are very many, I will just pick out three. First, she was the Young Engineer of the Year in 1979 for the Society of Women Engineers. In 1991, she won the Distinguished Alumni Award from the University of Michigan. In 1993, she received the President's Award for Intermodal Transportation from ASHTO.

Gloria Jeff Associate Administrator for Policy, FHWA

MS. JEFF: There is no symbolism to the fact that I was sitting here and Grace is sitting there. There is much more of a tie between Federal Highway and Federal Transit. It had more to do with the fact that we both were attempting to polish the quality of our remarks for such an august group and we needed separation in order to do that so we would be able to appropriately give this group the quality that it needed at this time.

What I would like to chat about today is in part about Intelligent Transportation Systems, but also how the transportation business has changed. That, more than anything, is what drives where we are today and what happens next, is that for those who began in the transportation business in the mid to late 1950s the world was very simple, the charge was very clear. Build the interstate system, period. Go out, hire folks that you need, the money has been made available for the first time, there is a dedicated funding source, your job is to build, your job is not to manage, not to figure out how the system is effectively used, simply go out there and build. And those who were given that charge did a very good job in that charge they were given in the mid-1950s.

Now the rest got smarter and older throughout that process and in that process we discovered that it is not enough to simply decide to build highways. There were other aspects of transportation that are important and we had to think about not just whether or not we could get trucks over the roads, but what happened with inner city bus carriers, what happened with transit facilities in metropolitan areas. We had to worry about whether or not roads were wide enough to safely accommodate bicycles and pedestrians and whether or not grandma could get across the street based on the timing progression that we set out.

We discovered that land use in the shape of metropolitan areas were impacted by the placement of highways. We discovered that we had real impacts on quality of people's lives because of where those highways were placed. We also discovered that there was a natural environment, a social environment and an economic environment that was impacted by what we did in constructing the interstate system. We suddenly went from having a very simple straightforward charge of building the interstate to a situation where we faced very complex issues. This complexity involved having those who were impacted by the system, as concerned about not only whether or not we built it, but how we built it, who was impacted by it, who won, who lost and whose opportunities were facilitated by it and whose were not.

Suddenly the issue was very complex. It was no longer highways only. It was not only urban areas only, but we were concerned with what do we do about the air that we breathe, the water that we drink, the noise that assaults our ears. Furthermore, questions were raised about how to make the most effective use of what had originally been an unlimited resource, the fuel tax, that had now become a limited resource for funding transportation. We also had to determine how to get some folks who we had not worried, or cared, about the process involved in it.

One of the tools we have discovered to help us deal with the issue of involvement, not to find all of the answers, but to help us, is a concept that for those of us who are in the 40 something generation. Remember watching Disney, and the Christmas shows that Disney would provide stuff, you may remember seeing somewhere in your background a vision of the future. This vision of the future had cars that, even though you sat behind the wheel, the car was programmed and it took you wherever you were supposed to go. Voila! We gave it a new name, Intelligent Vehicle-Highway Systems, and suddenly discovered that those dreams that we saw as a child might help us find some of the solutions to the problems that we have today.

As Hal Kassoff said earlier, or I said for him, after he told me -- this is one of those third hand situations, so recognize it is third hand -- is that the Intelligent Transportation System has great promise. It provides tremendous opportunity in the future, but in and of itself is not the sole solution to our environmental problems. The interesting thing Hank said was that it provides us with a mechanism to begin to link some of those solutions together. Those are the opportunities and the challenges that Intelligent Transportation Systems present to us.

The opportunities for linking Intelligent Transportation Systems and environmental quality goals together can be realized, but there are a series of questions for which we need find answers. One is, while in our Disney vision that we had as a child, ITS was one very single thing and that was the car you got in and it was automated and it had things that took you wherever you needed to go. The ITS reality that we deal with is not one single technology or service. It encompasses a whole variety of things. I can remember being in Germany in 1979 and seeing the beginnings of some of the intelligent transportation systems. In Hornberg, they already had a system where they could automatically locate all of their buses and not just know where the buses were, but know if they were on schedule or behind schedule. They were able to know if there was an interruption or an incident that had to be managed and how they had to reroute buses to accommodate that or turn buses around to maintain the spacing.

That was the beginning of the Intelligent Transportation System as I saw it. It includes not only how do we deal with public transit vehicles, it deals with international issues, with how do we more effectively get trucks across the border between the U.S. and Mexico and the U.S. and Canada and how do we bring together that in a way that helps improve the environment. That is because it helps us deal with the question of our natural environment initially.

Now let me just talk about the natural environment for a little bit. It is that it helps us reduce, or we hope that it will help us reduce, the air pollution that comes from vehicle idling. We also hope that it will help us begin to recognize that we have choices in terms of how we move. So while those in California, with all due respect to Californians, hope to change the need and desire of people to make trips, what we need to be able to do is get them to change the method by which they make the trip. Not one of the folks in California who says reduced trip making is the answer will not make the trip if they are willing to walk. What we want to preclude is making the trip in the vehicle by themselves. So the key is: "How do we get them to do some things differently?"

We think that Intelligent Transportation Systems will help us do that because, as we make it more efficient for goods to get to market, for raw materials to get to plants, we may be able to reduce the amount of vehicles that need to be on the road. We are able to have business and their suppliers located further and further away from their source because of just-in-time delivery systems. Delivery systems that utilize transport systems in which they have a very sound sense of how quickly those vehicles can get there, how they may be able to move more goods and not warehouse as much then we may not use the land in an inappropriate way. This will, hopefully, help us do some other things with respect to the environment and the creation of green space and better utilization.

The opportunities are there for intelligent transportation systems to work with environmental quality goals. It is not an either or situation. This is one of those unique opportunities where there is a win win potential. If we recognize that when we work together we all win. It is not a question of whether we have clean air or people have jobs, but rather the issue is how do we balance the two of them so that we accomplish both? It is not a question of whether or not we locate. Nor is it a question of whether or not we improve public transportation in a particular community that places at risk a minority community which has greater incidences of asthma and other respiratory problems because all of the bus garages are located in their neighborhoods. It is not an either or situation. There has to be a sensitivity to those issues as one looks for the balance in transportation and environmental quality goals and objectives.

Should we continue to promote the deployment of Intelligent Transportation without knowing all of its impacts? That is an interesting question. How many of you have a crystal ball? How good is your crystal ball? I will pick on my friends in the environmental community because I know that they know I love them eventually. We have a body of law that absolutely was intended to clean up the negative impacts of bad materials, we wanted to clean up our cities and we wanted to make them better places for people to live. We have a body of law that intended to do that.

One of the unanticipated impacts of that body of law was that we now have large central cities that have large tracts of undevelopable land. It was not the intent, but no one could have foreseen that. Should we have waited until we figured out that there was such a potential? I do not think so. We needed to be careful. We have learned some lessons. We have an opportunity to adapt and grow and that is the same thing we ought to be doing with Intelligent Vehicle-Highway Systems. That is: do not rush out and be on the bleeding edge because bad things happen when you bleed to death, but rather try and be careful in the deployment so that you at least have the ability to adapt to some unanticipated impacts. That is what they are, unanticipated.

My crystal ball is not that great. It gets a little fuzzy after about two minutes into the future. It is just not real good at predicting impacts. As much as I would like to think that it is about like everyone else's, I face the possibility that maybe I am the only one whose got a crystal ball that works that badly. For those of you who have better crystal balls, please help us so that we have a much better handle 10, 15, 20 years out as to what the impacts may be of Intelligent Transportation Systems.

One of the interesting things as we look at it from an environmental and a transportation standpoint, are some early winners with Intelligent Transportation System. One winner is the whole question of incident management. We have been able to better focus on that aspect of congestion. We have been able to reduce some of the air pollution that occurs as a result of vehicles idling in traffic simply because there has been an incident on the road. Hal Kassoff talked about that and the fact that that was a first step. It did not solve the air quality problem, what it has done is help us deal with at least one isolated aspect of the problem and focus some attention and some resources on it.

We have an opportunity with transit in the United States just as we begin to realize a system that the Germans in Homberg had in 1979 of knowing where vehicles are and knowing how close they are to schedule adherence. Schedule adherence is important because people say that one of the things that has to happen in order for them to ride public transit is to know that the vehicle is going to show up on time, be clean, and go where they want to go. So schedule adherence becomes important in terms of improving the attractiveness of public transportation. It also provides some safety aspects in that we have the ability to utilize some of the technologies that have come out of intelligent transportation systems. Some provide a greater assurance of safety in terms of incidences that may occur with accidents or that the driver may observe as they go by that they may be able to help with by having the automated systems.

Commercial vehicles have also been benefitted in that we have the ability now to assure that there is a uniformity among the drivers of vehicles, that they are where they are supposed to be, that they are not driving longer than they ought to be, that we have drivers that are coming in from Canada and Mexico who are meeting the same standards that we have here by having those systems checked out, but also by not having a lot of diesels running while they go through inspections at border crossings. So again, there are some opportunities that, although

limited, have promise. In and of themselves they are not going to solve the air quality problem, the noise problem, or the water quality problem, but they are part of the solution.

Some other early winners have to do with the whole concept of toll collection and the fact that we can begin to talk about automated toll collection systems. This begins to make the concept of congestion pricing more attractive because we have a way to do it that is not disruptive. There are other issues associated with congestion pricing, but at least there are some opportunities that we can consider.

Utilizing the national highway system, we have an opportunity to showcase some of the intelligent vehicle highway aspects of Intelligent Transportation System applications. We have operational guidelines which will be utilized or should be considered and cooperatively developed and implemented as we look at uniformity in this higher level system. That opportunity should not be missed, because as we look at these higher level transport, this higher level system, there is an opportunity to get the most effective achievement of environmental goals and transportation goals with respect to highways. As we look at public transportation and as we look at airports and sea ports, the opportunities for some of the same kind of technologies are also there to make improvements. So it is not simply the national highway system, but there are opportunities in the other modes as well.

Can state and local governments work cooperatively together with the private sector with the other stakeholders to plan and deploy? Our last panel did an awful lot in addressing that issue. As I said in my closing comments, there are several messages with respect to the plan and deployment of Intelligent Transportation Systems. Yes, they can be done in a cooperative fashion, yes you have to have all the stakeholders there, and interestingly enough, yes ISTEA does provide us with a mechanism via the statewide and Metropolitan Planning Organization planning processes to provide the institutional framework for those conversations to take place. So, as we look at transportation in its totality in a statewide or metropolitan context, we will have an opportunity to see how Intelligent Transportation Systems fit into that context. Going back to Hank's concept of linking together via the management systems and the metropolitan area planninggoals how Intelligent Transportation Systems fit should be clearer.

Do we understand all the policy tradeoffs between the Intelligent Vehicle-Highway System and its deployment to support national goals and local community impact? No, we do not. As was said in one of the panels earlier today, there is a need for more data, there is a need for a better methodology for looking at intermodalism and the intermodal evaluation of transportation decisions. Should we not move forward with Intelligent Transportation Systems because we do not have that? Absolutely not. Should we be cautious? Absolutely.

There is an opportunity to maintain balance. There is an opportunity to look at transportation and environment so that they are supportive of one another. As Cindy said, you environmental folks will not go away and you ought not go away. You ought to have a seat right at the table, but you ought to have a seat at the table along with the rest of the stakeholders. The key is not whether you as an individual entity win, but whether, through the collective ideas of all the stakeholders at the table, there is a solution found that is most effective and most reflective of the community or the state. This should be in terms of their own goals and their vision of what they want to be and how they want to be and we ought not limit ourselves to our own individual perspectives. Not as a highway engineer/transit person, or as those who come to the table concerned about whether or not grandma can get across the street, or as those concerned about whether or not we have a new product on the market to sell, but rather how do we all work collectively together as stakeholders in transportation and of the world in which we live in a way that works most effectively for all of us.

In closing, I want to end with the concept that transportation and the environment are not in competition, but that there is an opportunity for a win-win result in all that we do as long as we come to the table with the perspective that an opportunity for synthesis and cooperation exists and not one for conflict where only one must win.

MR. BURWELL: Thank you, Gloria for those very substantive remarks and for reminding us that we in the environmental community often forget that prediction is very difficult particularly with respect to the future.

Our next speaker at the other far end of the table is a good friend of mine, Grace Crunican. Grace has scribbled down her resume for me very quickly. But I do just want to take a minute to embarrass her a little bit, Grace was the Executive Director of the Surface Transportation Policy Project prior to taking her present job as the Deputy Administrator for the Federal Transit Administration. Grace did come on board with STPP at the perfect time, a person at the right place at the right time. It was a time when ISTEA had just been enacted and very few people even knew that the law had been enacted. In fact, there was nothing in the Washington Post covering it at all. We had a big challenge to get the fact that this law had been enacted and there was a real opportunity for citizen participation under the new law and within the community.

When Grace took the job she thought about what she was going to do for about a month and then announced that she was going to have 11 conferences within a four month period all around the country informing citizens of this new law. Having tried to put on one conference in about 18 months, I thought this was absolutely impossible. Nevertheless, these did occur, 11 conferences in four months. I believe over 4,000 people came to these conferences. Eight state DOT Secretaries attended the conferences and they were a tremendous success in informing the general public of the importance of this new law. It was very telling that Secretary Pena, who wants to promote a more community focus to transportation issues, selected Grace for Deputy Transit Administrator.

Grace has her BA in Political Science and Criminal Justice from Gonzaga University, a Master's in Administration from Willamette in Salem. She was a Presidential Management Intern in the Carter Administration with U.S. DOT where she was assigned to the Assistant Secretary of Policy and Budget. She then spent two years in the Appropriations Committee for the U.S. Senate. She then worked for the City of Portland as the Capitol Program Manager. She then became Executive Director of STPP and now she is the Deputy Transit Administrator. Quite a career in transportation and thanks for coming, Grace.

Grace Crunican Deputy Administrator, FTA

MS. CRUNICAN: When reviewing the agenda of this conference and particularly when I heard about what happened last night, I made some quick changes in my remarks. Instead of telling you all that we are doing in the Federal Transit Administration and walking through APTS and some of our other technical work, I thought what would be interesting -- I took the remarks of Larry Dahms and David Burwell a little bit seriously -- and wanted to tell you that 1 am one of your customers. So I am going to take the opportunity to sidestep all of the esoteric questions that you have been going through. Instead, this is an opportunity for all of you to climb into my shoes. The job is not that easy, but it is not impossible. Gloria and I have made it through these positions, but it is not that easy and I would like to enlist your help in it. What I thought I would do is walk through what it is like to be the Deputy at FTA. I am not going to take you through a daily schedule, but there are some questions I am pondering and I thought I would let you see what is inside my brain. I am one of your customers and, if you could just assume that you are one of my consultants, it might be helpful for you to try to understand where we are headed in the transit industry, or maybe I should say where we can head

So forgive me, and forgive my professors, they were very good professors. If I do not sound like I have had very much of an academic background, I have just rolled up my sleeves and tried to do the job the best thing I can. The best thing I can do today is lure you into my vision of where we could head with transit. Too often the industry, the intelligent vehicle and highway industry -- and for me it is just technology -- the technology world has not felt very comfortable with transit. You have done a terrific job overcoming that uncomfortability, engaging in transit. We are very much a mainline piece of what you do, but I need you in my portfolio in the transit industry as a whole. So I thought what I would do is talk to you a little bit about the constituencies that we have at the Federal Transit Administration.

You are one of our constituents, and I need you in the mix that is defining what the transit future is going to be. I will be just slightly bold enough to say that I do not think the last 15 years -- I will go back to the Administration I was a part of as a PMI -- I do not think for the last 15 years we have actually believed that there

was going to be much of a healthy transit industry out there. I do not believe that we were planning for the transit industry in the same way that we are planning for the highway industry. The highway industry has been very cared for and nurtured but we need to apply that same nurturing, if you will, to the transit industry and consider it a legitimate future in which to invest.

When I first got to FTA, actually before I got there when I was still at STPP and knew I was going over, I started interviewing folks and I ask them, "Who is the FTA constituency?" I tell you I got more answers on who is not the constituents for FTA. I am not talking about transit, I just meant in terms of FTA. It was not particularly APTA. APTA felt -- the American Public Transit Association -- as though they had to defend their turf and there might be a working relationship. But they did not consider the FTA one of their constituents. It was not ASHTO, although ASHTO does have a very active public transit element to it. But the first hand that they reach out to on the ASHTO side is the Federal Highway Administration.

So I began to wonder what constituents were out there. It was not the vehicle manufacturers. The vehicle manufacturers had nothing good to say about the FTA. It was not the environmentalists particularly. In each of these cases, you would have thought it was them -- and it was not poor people. When I was at STPP talking to some communities that were fighting for their life, they did not have transit on their scope at all. They were dealing with education issues and safety issues and they just did not have transit on their scope. But when I took the job, I was thinking to myself, let us see I must have the vehicle manufacturers in my portfolio, I must have ASHTO, 1 must have APTA, I must have the basic mobility people that are out there, and I did not.

Gordon Linton and I have talked a lot about the policies, but as a personal charge, what I have on my agenda for the next five years is the recreation of a constituency for transit and getting them all together and then visualizing what transit can be. Because there are many people around the country that think about what highways can be. In fact, the issue is not highways and transit. When I looked at it -- and we are doing a lot of research in this right now so I do not have definitive numbers -- but I was trying to figure out who our client base is. We have three direct servers who are on the bus riding if you will. One is what we call the commuters, one is what we call livable communities and that is the element of folks that are basically served by their mobility needs, they have a choice, but they choose transit. They might be in New York City, they might be in Boston. But they are basically where they have both rail and bus systems in the basic metropolitan area. Those are different than commuters because the commuters are getting to and from work and we call it livable communities -- that is the rhetoric that is going on, so I do not know if we were not there what you would call it, but folks that have choices but choose transit to run some errands or go to the theater.

The third group is what I call the basic mobility group. Anywhere between 30 and 33 percent are the numbers we are seeing of our clientele that either do not have a car, do not have access to a car, or are disabled in some fashion or have some kind of disability be it age, vision, whatever. So in terms of our ridership, we have three groups of customers that are "every day." That is my first constituency -- those people. What can I do to serve them? I am going to come back and walk through some questions in regard to these.

Another constituent is Congress. To Congress we are a piece of the pork barrel. There are Congressional folks that died to get an earmark for their transit project, bus or rail, but we do not have a large group of people that are standing up for transit as a basic piece of the fabric, the infrastructure fabric of a community that provides basic services. That is, if I go to the Health and Human Services Committees, they do not think of me as part of their system. When I go to banking, they know they have to reauthorize the transit program, but they are not thinking it as a part of the urban fabric. It is an entity unto itself.

A couple of other constituents I am just going to bullet through because I want to get to some of the questions I am asking. Local elected officials, manufacturers, and there is a whole separate agenda going on there. The last one I will just mention is the HHS side of things. The constituency was not put together and I want to reverse a couple of these questions or take a couple of these questions in reverse order. So I am going to start with HHS.

One of the jobs of the Deputy is to sit on what is called the DOT HHS Coordinating Committee. For those of you who are engaged in the environmental world and the technology world, this element of transit probably has not come across your scope but I am telling you there is a real hot product out there and there is a real use of ITS coming. I need you engaged in the problems I am facing in this area big time to get us out of a dilemma that is coming.

The dilemma is this. I have about a \$4.8 billion budget in Federal Transit. In the federal Health and Human Services budget, they spend over a billion dollars on transit service. Now the reason I know it is over a billion is because I saw a figure that said \$1.2 billion with a lot of little asterisks on things-that were not included. When I got further along in the research, I found out HHS does not want to say how much is used in transit because they are afraid someone is going to say delete transportation from their budget and then subtract out that amount of money and not provide them that. So I am guessing it is probably between \$1 and \$3 billion that they have available in Health and Human Services to" spend on transit.

What kind of transit service is that? Medicaid patients, elderly, Head Start, AIDS patients. There are all sorts of special programs and they have nine stove pipe agencies over at HHS and guess how many transportation experts they have? One. She is responsible for coordination of transportation services.

So on the first day of the committee, I am a shy person as you can probably tell, I said, "Let me just be clear about our motives at the FTA. You spend over \$1 billion on transit and I want to split the baby in half. I want to give half of that money back to you to put into your services and I want you to invest half of it in my services because I know we can provide your transportation needs for at least half the cost that you are paying right now and it will make my systems healthier." Because it will take the money that we are putting in HHS in a disorganized fashion. I do not win friends with the private sector on the first half of this conversation, I do on the second half. But you are spending far too much for these trips. You have heard the horror stories. They are as bad as the \$600 toilet seat or \$600 hammer. The travel is taken, but put it back in my budget and give some of my smaller providers and my larger providers para-transit systems, my smaller mainline providers access to those funds to provide basic mobility so that the folks that only have access to a medical trip can now have access to go to the video store or to go to the market or to go out and visit a cousin that lives not too far away. So if we could provide a better level of basic mobility because we have better spent that Health and Human Services dollar, we are adding to the lives of those people that are only getting one trip.

So, here are some questions I have of you in regard to this HHS dilemma. Now the reason this is a hot potato is because we are reauthorizing the Health and Human Services Programs right now and we will be doing welfare reform later. It is going to take a while to do that. But as we do, the issue of coordinated service on the state level is a very hot topic right now. I just spent three days in Pittsburgh with the Community Transportation Association and people are trying to merge at the local level these Health and Human Services provision of services with the transit provision. As we do, there is a lot of questions, such as efficiency. How do we most efficiently serve the needs of the disabled patients, the aging patients, with those of the fixed route service? How can we bring those together? What kind of information do we need to have?

From a technology point of view, we have a demand responsive set of clients over here. Some of them are scheduled regular trips like meals on wheels. The reverse of that, bringing the seniors to the citizen center, but some of them are very much demand responsive trips. How do we do an assessment of their needs? How do we plug those needs into the mainline system? And in the future, how do we on a very large scale institute this system? To me, leveraging this constituency into transit, exactly what you need when you are trying to advocate because we have a government funding source of some kind as a base level of support, it answers some of the same questions as your suburban -- I have seen a lot of people spend some time on the suburban commute and how do we provide some kind of communication system on the demand responsive.

In addition to immediate efficiency, I am interested in some long term monitoring of the problem. That is, "How do I look at where productivity was achieved, where is it best achieved, what kind of coordination works best and what kind of systems do you have in terms of accounting for that?" I mean any kind of system you put in place in terms of collecting the data and matching up rides, if you will, needs to be used in the long-term to

provide a story. Because one of my other clients is Congress and Congress wants to know how it is going, what measures have you put in place, where are we making gains, where should we invest our money in the future? So I need you to keep track of where the trips are from a distance, a few feet above, maybe 10,000 feet above the system that is going on and figure out where it works best. Now some of this is going on. I do not mean to pretend that it is not, but we have got a huge client out there.

Let me go back to Congress for a minute. Congress does want to know and is interested in the pork projects. But likewise, they are very interested in trying to balance the budget and come up with efficient programs. One of the things that is completely separate from this HHS issue, one of the things I need to do, and I need to engage in the long run process is something like Gloria's Needs Report. This comes out every two years and I have a Needs Report that comes out every two years. Gloria's system is based on the Highway Performance Measuring System, Monitoring System, HPMS, soon to be hers. We can hold another conference on that if you like. But her system looks so established and regular -- 1 want to say regulated, but the standards have been set for pavements. The employees of the state DOTS have been trained to go out and measure. The information comes in and whether you want to refute HPMS or not, it is the mechanism we use in the Federal Department of Transportation to establish needs that are out there.

In the FTA's world, what we have are miscellaneous surveys that go on periodically and we do not just have one statement of what the needs are in the transit industry, we have several statements of need. ASHTO comes out with their statement, APTA comes out with theirs and the Federal Transit Administration comes out with theirs. They are in varying levels. Generally speaking, FTA has under estimated more than ASHTO, which has under estimated more than APTA But we have no consistent reporting mechanism to provide Congress with some balance.

Now, you are sitting out there thinking, "What has this got to do with ITS?' There is such a market to systematize our way of doing business in the transit industry that it is outrageous someone has not jumped onto this and made a million bucks or more off of it. I guess that is small potatoes for some of you in the audience. If you go down to the transit level, just imagine this concept parallel -- Gloria referenced just-in-time planning. The only way you get to just-in-time delivery of products is if the person running the cash register taps in 501 jeans, size slim, and that information gets translated to some computer which does some thinking for it. This is what the intelligence function is on this information gathering. It is not only that they were sold, but where they were sold. It figures out what else is being sold that day and what kind of merchandise they need to put into that computer for that day.

Likewise, what is going on is someone is sitting back analyzing and the system is providing some of the data and some of the thinking goes on by the individuals. What is the market? We have sales and marketing involved here. We tap in this 501 jean seems to be going on, or more importantly we are switching from 501 jeans to Dockers, some of us, a little extra here. So someone is out there analyzing the information that comes in from that little cash register. Every little cash register in every little Gap Store around, whoever is out selling, and it comes into the main computer and someone is thinking there is a trend going on here. These Dockers are pretty hot and someone begins to put information together. Let us see, people are getting older and wider, and so maybe we need to shift our thinking slightly.

That is the kind of thinking we need in transit. I need a system just like that. I need Gus and Doreen, the bus mechanics, when the bus comes in at night to tap into their machine, I oiled this, lubed that. They are putting in what the customer asked for that day. The bus is the customer consuming oil and lubrication and air conditioning kinds of things. But, you need to take that thinking to just-in-time. Because the just-in-time thinking at the cash register led to not only inventory delivery but where the company needs to go in terms of its market.

Believe me, I do not want a direct line link on the information highway from every bus mechanic that is out there. Do not misunderstand me. But, there are three layers here that must be acknowledged. The first one concerns what this bus needs and some analysis of the bus. If this bus comes in and needs 12 quarts of oil every day, something is wrong. A feedback system is in place. We are working on this and it is in place in some facilities. But you need information on the bus. Then we need information on the fleet. That is where I begin to get interested. What fleets produce what kind of mileage, what kind of consumption of oil, what kind of environmental output are we getting, what are the exhaust measurements, how long do they last, what is the quality

of this over that? Manufacturers may or may not be interested in that, but that accumulation of data comes in and we need some analysis of what is there.

Likewise on a national scale, we need to begin to combine the information. Right now what I am talking about is public transit management systems, PTMS. Even though the requirement is out there on the management regulations that we have, we are not oriented toward asset management. We are oriented toward the relationship to congestion management and other issues. But the asset management piece which parallels Gloria's Pavement Management System is not in place.

So we need institutionally to get that piece together, then we need to plug some of that thinking into national projections associated with where we want to head in the future as a transit program. That has to do with how much of the market can we capture. Now there is a bunch of you sitting in the audience who drove here, who drove home, who are thinking, "This transit thing, I do not know if it is going to go anyplace." It is because we have a lot of shifts underway right now. If you can buy into the fact that it is moving and your company gets paid to buy into that for just a minute, then the question is where, what can it do? I need your minds thinking about what can it do not what is wrong with transit. What kind of capacity can we alleviate? That is where my system needs to match up with Gloria's system. Because Gloria's system is going to say we have traffic demand over here and then we need to get into that question of how much traffic demand can we move from a highway to a transit. You are accustomed to some of those thinkings. But there is a lot of technology needed in the first part of the asset management to figure out how much it costs, how we can get leaner and meaner to make that linkage.

One more miscellaneous thought that is going on in terms of questions that we are asking. It gets back to the customer. I think you have covered this, but I wanted to just talk about it briefly. The customer sitting out there has in the past been thinking of transit as maybe a backstop to the car. Maybe they are a regular user, but they have different sets of questions for different sets of customers. Our customers are not monoliths in their approach nor should our approach to our customers be monolithic. In the past we have had a monolithic approach to them. What we need to do is begin to break down the customers into various categories.

I started off by talking about the commuters, the livable community side of things and the basic mobility issues. These customers have a different set of questions and we have some techniques in the technology world to address those. The commuter customers -- this is again Grace sitting at transit listening to folks -- are interested in reliability and timeliness. They know where they are going, which bus they are taking. They take the same bus every day. They are interested in reliability and timeliness. We have some information systems in place in BART and in other systems. You are very good in the ITS field about providing that information. We need to instill it in more transit industries, make our capital program large enough to include some of that information, to keep the commuter coming to transit, to get the information there quicker so that they know how much time they have for the next trip and to see their options.

That gets expanded even further in the livable communities. The people that have options in terms of whether they want to take their car or take a transit trip, we are more likely to lose these people than the commuter actually, The commuter we have some methods of ride sharing, but their point of origin and destination is the same. The person that is figuring out how they want to go about making an auxiliary trip, a non-discretionary trip, if we lose them right now, it is going to be harder to get them back because they are not going to the same place tomorrow. So the information that is available should provide options availability when options are available. There we need to provide different information. That is where the intermodal link comes in. That is where I need to know if I have a train, a bus, or carp001 option. That has to do with information services, it has to do with basic information that could come across your TV set. The other piece I am talking about is something that you have at the transit stop.

The third piece is basic mobility. These folks are interested in predictability and also in being treated as a customer. I am not sure this is a technology question so much as it is a transit industry approach. We have to stop taking these customers for granted and treating them like a piece of trash. We have too often taken them for granted and not gone out and figured out how to capture the market. That is where I put the question to you. I am not sure what the technology community has to offer them. But there is a group of folks that are steady, stable,

reliable customers. They are dependent on transit more than anybody else and the service that we provide them needs to be both informational in terms of the system that they have and supportive in terms of other customer conveniences. I will leave that one with you.

Before I close, I would like to point something out that I am not sure it is been pointed out. I have not been at your conference all day, but this is a much different audience and this audience keeps growing. I mean we have been at this hotel a number of different times and it is not just the ITS audience, but it is that group of folks that are engaged in trying to look toward our transportation future. I guess I would like to see just for my own sake, how many of you would identify yourself as having five years ago not been the slightest bit interested in being at this conference?

Pretty good, since it was a lousy question. That is a real important component because the intelligence that the traditional ITS community has is incredible, but it needs to be matched up with a customer. I know you have wrestled with those questions. I would just as soon you stop wrestling with those questions and get on ahead, but I would like to give you my own applause for the mix that is been achieved here today and not just a today. I have seen it grow over time and I have seen the audience diversify so I would like to thank you for that as well.

SUMMARY OF BREAKOUT GROUPS

Moderator: Christine Johnson Vice President, Parsons Brinkerhoff Quade and Douglass, Inc.

MS. JOHNSON: I am pleased to be here. First of all, the diversity that is represented here is genuinely exciting. The people that are represented, the groups that are here and represented. I just walked in and immediately felt this is where the future is is in the people, not necessarily the technologies we were talking about.

So, it is a pleasure. I probably only got it because I came away from a fairly traditional transportation engineering, where we were discussing how to build a model to the exact nth that will predict how many SOVs are going to go over to HOVs and so on, as opposed to how we might get consensus to even have it.

What we are going to try and do today is have each of the moderators very quickly -- and you that participated in each of the sessions may feel a little bit cheated here -- I have asked the moderators not to try to go through their flip charts and not to try to go through the carefully worded recommendations, but to step back from the session you just went through and think about the three primary themes that emerged from the discussion and to very quickly present those.

Then we are going to ask Edith and Phil, who I am assured have been introduced here, and I have very carefully prepared a set of introductions, but I am throwing that away for the sake of time, to then come back and try to wrap this into something of a package or of a whole and throw out is this what we are saying as a group of people, who have worked together for the last two days as some of the beginning steps of how ITS and the environment can engage.

I am sure you will be unhappy with that. At that point, I will then throw it open to you and we will see what happens in terms of the give and take. We are at a closure point here and I would throw out to begin our final deliberations with this thought -- "I wonder if this conference were held around Edison's time and we had the environmentalists and so on and whatever would be the equivalent of the electricity people saying, well, how do we engage and how do we estimate the environmental impact of electricity?"

I mean, can we even think of the breadth that that would have, the impact on society that that would have? Sometimes I wonder are we asking the right questions. Ought we instead to be trying to envision several different alternative futures and all the different implications? Should we not, using our imagination, using these technologies ask what might the impact be, as opposed to going for the jugular and the project right now?

That is my contribution to the beginning of the discussion. So, start with Group A.

GROUP A: NEW STRATEGIES AND TECHNOLOGIES Spokesperson: Steve Burrington

MR. BURRINGTON: I was asked to boil it down into three points and be brief.

The first theme of our discussion has to do with the development of a common vision for the intelligent transportation future and this is a very important concept. It is as if we had the opportunity to go back to the early 1950s or the late 1940s and have some of the people who were trying to block highway projects in 1970s they are working things out up front.

We are obviously developing a new generation of transportation systems here, and if we can get things going in a mutually agreed upon direction early on, it will save us all a lot of time and aggravation later on when we are just trying to mitigate or reconcile or whatever.

There were a few important points made under this theme. There seems to be a need for both the environmental community and the intelligent transportation system community. We recognize that both of these were not monolithic communities, but using that shorthand, there seemed to be a need for both of them to articulate their respective visions of the intelligent transportation future and then to work toward a common vision together. The sense was, I believe, that this was something that would take some rolling up of the sleeves but that we ought to get to work.

I think implicit in that, a number of people said environmental interests need to be mainstreamed or included in the future development of intelligent transportation systems. There seemed to be two general components to that. First of all, people thought that in a number of for a more environmental groups, representatives of environmental interests needed to be participating. Second, it seemed to be thought that if the intelligent transportation system folks would focus on ISTEA, think about what ISTEA meant, what it was the culmination of, that that would help work the mainstream the environmental concerns.

Finally, under this heading of a common vision, there was a proposal that we work toward agreement on the early implementation of some measures; we work to identify some things that everyone agreed would be wins and that perhaps those could be the nucleus of, you know, a broader consensus later on.

Our second general theme was evaluation. It was generally felt that we needed to have some common measures of effectiveness. No one was prepared to come up with a definitive list of those, but they might be things liketime savings, air quality improvements, VMT reductions or energy efficiency. But we need some common measures of effectiveness. We need to develop the methodologies to use in evaluating intelligent transportation technologies, and according to those measures, to be able to compare different technologies against one another, road-based technologies versus others. We need to start developing a cost effectiveness protocol for figuring out cost effectiveness along these measures.

Third, and finally, and this is a messy heading, we all agreed that there were certain things that needed to be done under the heading of technologies. That is a terrible heading, but that is what we call it.

Under the heading of technologies, there was the idea that wherever possible, multi-modalism should be part of intelligent transportation systems. That the technologies should either have multi-modal capability or it should be figured out that it did not make sense for a given technology to have a multi-modal capability.

Next under technologies, a number of people pointed out that intelligent transportation system work needed to account for both existingand emerging information technologies. That we needed not only to take stock of stuff that was already out there on the shelf from other areas, but also to link ourselves to the information superhighway folks, whoever they may be. Finally, there was a pretty strong feeling that the work being done on alternative fuel vehicles, including electric vehicles and alternative sources of power for transportation generally, work being done in that by the Department of Energy and others needed to be integrated or coordinated with intelligent transportation system work.

MS. JOHNSON: Next, we have Group B, Energy and Environmental Implications.

GROUP B: Energy and Environmental Implications Spokesperson: Douglas Ham

MR. HAM: This was quite an interesting exercise, I think, for everyone in the group. We had an extremely active and vigorous group. I think Phil and Charlie Goodman and others sat in for times.

When Mark Miller got up this morning, he mentioned seven issues that we had decided on yesterday as being important. What we did in starting out today was get that down to three issues, some of which match Group A's general direction. Out of that, we came up with 16 very specific action items which we will provide Phil Shucet and Tom Horan for future use.

Our first issue was that on an ongoing basis, we need to revisit the ITS mission to more accurately reflect society's environmental goals and objectives. Just quickly, a few ideas, specific action items. We need to identify and explore the usefulness of various analytical techniques that will allow us to get inside the heads of the public and other stakeholder groups. For example, the technique of deliberative polling, needs examination to see if it is a technique that might be useful. In addition, the strong sentiment to change the name of ITS AMERICA as part of the overall mission revisitation, the concepts of more outreach, using DOT field personnel more effective, using ITS AMERICA regional chapters, student chapters, and tie them altogether in more effective outreach type efforts. A very strong concern that, however we do this, we always take into account the regional diversity that is typical of the country. We do not try to force feed or put one size fits all on top of the whole country.

Second -- and this gets to the common measures idea that Group A addressed -- there is a need for improved research and data regarding the benefits and costs associated with ITS so as to allow improved public policy decision-making. And under that general topic, we had: a need for more and better forums in which to share the information than what we already have on the analytical tools. One of the very specific items that was mentioned was an electronic bulletin board that will describe models that are available; a need to encourage DOT to continue improvements in modeling and data collection; a need to develop betterjoint research efforts between DOT and EPA.

Our last big issue was a need to develop a consensus-based process that allows technologies with positive or neutral environmental impacts and otherwise clear overall benefits to be deployed on a fast track basis. In this we had several issues. First have DOT fund several local efforts to look at ways that technology applications could be effectively bundled so as to maximize the environmental benefits or maximize benefits overall. Or maximize environmental benefits while minimizing any negatives and have that local government use the funding in a local deployment plan and build from there.

This concept of bundling kept coming up. As a result, the structuring issue, a positive approach, wholly outweighed the negatives in a cost-benefit sense.

A second thought that ran through all the issue was the National Environmental Protection Act (NEPA) and its role and how NEPA ties into ITS issues. As a result, there was a finding that we should look at user services overall and see how NEPA might apply to any given one. Additionally, there should be funding of several local efforts that address more specifics at a local area and see how NEPA might interact with an attempt to deploy ITS technologies.

MS. JOHNSON: Thank you. Our third group is institutional issues.

GROUP C: INSTITUTIONAL ISSUES Spokesperson: Peggy Tadej

MS. TADEJ: The institutional issues group had five summary findings. One was to strengthen the MPO role. Under that we had several different categories. They were unified federal guidance to the MPOs, training and technical assistance, direct federal assistance to community-based organizations and using MPO requirements and certifications to reinforce early deployment programs.

Our second finding was the need to broaden ITS coalitions and develop institutional linkages. This responsibility would be at the national, state, regional, and local levels. There was a strong view that at the state DOTs and at the MPO levels, and across the whole board of transportation, every organization had a mission statement that was behind the times. As a result, our finding was that these organizations needed to broaden the mission statements by adding performance measures. The state DOTs need to take a long term, least cost planning

approach. Intermodalism was considered essential and we concluded that, between FHWA, FTA, FRA, all of those needed to form a task group and, although we thought something like that had been done, the environmental community needed to be included.

MS. JOHNSON: The final group is societal implications.

GROUP D: SOCIETAL IMPLICATIONS Spokesperson: Ellen Williams

MS. WILLIAMS: There were a number of things that came out of our group here and I am going to attempt to try to capture all of the action items that were recommended. But I would like to start off by saying that it was a little bit like a Fortune magazine article cover that I saw not too long that was captioned, saying "Meet Your New Boss, the Consumer." That is a lot like transportation today. I think the message that seems to be coming out throughout all of these workshops is the message that we have to get to know the consumer. We have to do a better job of hearing what the user of the system wants from the transportation system and we have to go beyond just public outreach meetings and forums. This implies that we may need to take a more exercised approach in terms of research, market research type activities, to get to know that consumer because we do have some disenfranchised individuals, who would not normally show up at public forum committee meetings needs to be asked, "What do you want out of your transportation system?"

Going on from there, we have to spend some dollars on that participation. We have to make a commitment in the program platform. Right now, most of the program money, obviously, is being earmarked to engineering the projects and the field operational tests and, thank goodness, it is now the evaluation portion of it. We need to add user participation at the front end, much like we now have evaluation at the end of a particular project.

We also need to do more in terms of the public education. What came out in our group, too, is that there is an awful lot of people here in the United States that are asking, "What is ITS?" "Who cares?" ITS has to be converted into a language that has meaning to the citizen, again, using the transportation system and even the MPOs. Even some of the MPOs are not terribly clear about what is ITS and what does it mean to our MPO.

So, another key point that came out here is that we saw a common thread through all the issues and concerns. This common thread is the need for complex modeling techniques, that recognize that it is no longer possible just to look at transportation needs in terms of modes. It is far more complex than that. It is an inclusion of the economic and societal and our racial groups, our ethnic groups. And, that it is a very complex thing. You know, what is exciting about defense industry conversion right now is that there is all those marvelous Cray computers laying out there, waiting to be used. And I cannot think of any better way to make some good use out of all that processing capability.

Going forward here, and the question may be asked, why does this belong in an ITS conference, but it had to do with land use. We recommended that the better models we needed must link land use. transportation and ITS. That focuses on the complex modeling issue we just talked about here and the cost benefit analysis of making choices of how we build transportation systems.

I think one of the very, very important points that came out of our group was that we have to stop and think, when we start working on transportation in ITS, how does that fit into the role of society? how does that impact society? That has to be an integral component of the planning and the decision-making process and it cannot be the techies on one side and the societal people on the other side. It has to be recognized that each is a very valuable component and contributor to the overall system and that each has to be valued as an integral component.

MS. JOHNSON: If you can hold on for just a couple more minutes because I am sure that some of you want to add to the summaries that your chairs gave, what I would like to do is turn it over first to Phil and then to Edith to see if we can put this into a whole framework.

SUMMARY PRESENTATIONS

Sessions A & B

Phil Shucet, Michael Baker Jr., Inc.

MR. SHUCET: I tried to write one paragraph, or set of phrases, based on my observations in Group A, new strategies in technologies, and Group B, energy and environmental implications, which was my responsibility. I also have the benefit of not only what you said during your presentation here, but also what I heard going on in the sessions.

I think in both groups -- and this is a combination response -- there was definitely a confirmation that the transportation and the environmental community do not concretely share a common vision at the moment. There was a definite affirmation that we must continue to strive for a common vision for ITS by mainstreaming the environmental and other public interest groups into the discussion.

Once we have that vision, we need to make a serious commitment to revisit the vision, based on the continual application of new, broad-based, public involvement techniques that are mandated by ISTEA. Realizing that we have made a commitment to revisit the vision, it was stated very strongly in Group B that we must make a real commitment to take action, based on that public outreach or public interest outreach mission and that we cannot resort to empty promises.

If we are going to promise to revisit a vision and promise outreach to a larger community, then we must be willing to take concrete action, based on that outreach effort and that all of this has to occur with the realization of these regional diversities, that recognizes the fact that ITS deployment is, for the most part, going to be local and regional decisions. So, were I to boil down to one paragraph the findings and recommendations from A and B, that is where I would leave it.

Sessions C & D

Edith Page, Bechtel Corporation

MS. PAGE: I have to confess to being surprised after sitting through a lot -- several hours over the past two days of very vigorous discussion in Groups C and D, the institutional and societal issues groups, that there was an amazing degree of convergence by the time it all came down to having to decide on the major issues. I have summarized that convergence as follows and bear with me. In some cases to make the parallels more complete, I perhaps have rephrased things in ones you might not completely embrace. I did listen very hard and you will just have to forgive me if it does not sound exactly like what you thought you said.

The first and major theme was very similar to the one Phil listed first; that is, the need to broaden the constituencies involved in the ITS planning and implementation coalition. The institutional issues group viewed this from the perspective of the state, regional and local; that is, the governmental institutions.

The societal issues included users and non-users and government participants as well. And the point was made that resources are going to be needed to make this process sufficiently participatory and it is very important to have a meaningful dialogue and some common working through to a goal, rather than a listening on one part and as one of our participants phrased it, saying thank you very much and then going off and doing exactly what they had planned to do anyway. That is not business as usual.

The second theme was more related to the process. In one group it came out as strengthening the MPO's role and using the MPO process for implementing the early deployment programs. In the other group, that came out as including land use and quality of life and social and economic issues, impacts of sprawl, land use issues, in other words, which is something that MPOs are very much concerned with.

The third issue, which I had to stretch to make a linkage. so, you are quite free to believe these do not link very well. In the one group, it came out as the need to think creatively about forging new institutional linkages, the need to change the way institutions do business, was considered important, and the parallel side of that in the societal group. For the parallel side, I used the issue of equity issues; attention to consumer needs, including the non-traditional consumers, the disenfranchised, as they were referred to, as part of the planning and implementation process.

wanted to share with you a phrase that I was unfamiliar with, but it is relevant for the inclusiveness. It is the phrase, "equitable bias." Every party, every stakeholder, comes to a meeting with some bias. The important thing for us in trying to shape the program for the future is to be sure that those biases are represented equitably and not give preference to one over another. That could certainly be applied to this conference as well. And I think the organizers have tried admirably to make sure that the process was equitable.

And the last clustering, and I want to emphasize the importance of this because it came through in area after area, was the importance of research and analytical tools. Both groups concluded that there is relatively little we do know for certain about this very broad-based constituency that we have. Ellen mentioned we need to learn to know the transportation consumer. Well, that is everybody, with all those individual variations. That is an extremely tall order. There are some good analytic tools. There are other analytic tools for sociological analyses that are not so strong. So, the point was made in both groups that we need to strengthen the capabilities of the existing research centers and take advantage of them and to reach out to other research centers to supplement our capabilities for the complex modeling and analysis that are going to be needed.

And, finally, the point was made that it is important to have some teeth in the requirement for including institutional and societal and environmental issues and considerations in the early deployment plans, the things that we are going to be doing very soon or that we are going out for now. The recommendation is that we use what we do know to help avoid mistakes, even as we are building our capabilities to learn more.

MS. JOHNSON: You now have some concrete themes that might serve as a closure to the two days that you have put in here. 1 am wondering if there are some volunteers that want to amplify, want to deepen them or want to add to the summary themes that have been presented here?

MR. SPRINGER: I am here from Minneapolis. My name is Tim Springer and I am representing the Midtown Greenway Coalition. My perspective -- I am a skeptic about ITS, but I have to say that I am a little bit of a convert after this conference and I was not expecting that at all.

MS. JOHNSON: Are there any other additions to the package that collectively we have put together? My understanding is that we will make some effort to try to write this up, try to get the detail of the recommendations together so that it can be circulated.

I also want to report that Edith, who chairs the Societal Implications Task Force, is going to take a next step in being able to do some visioning that will be a little wider than has been done before. So, that may get underway. I know that there is some effort in trying to create a research agenda. I think some of what has come out of here can go into that.

Comments?

MR. REPLOGLE: Yes. I think we have had a pretty good summary here. I would like to just inject in the summary one other notion, which I think -- and it surfaced at various points and is certainly related to some of the summary comments, but that is a specific item relating to the ITS program plan and the need to revisit the

elements of user services there, specifically to include automated speed limitation as a specific user service. There were comments to that effect made last fall, but they did not have any effect on the newest edition of the ITS program plan.

MS. JOHNSON: For those of us who are paying an unnameable surcharge in our insurance rate for having too many tickets, I think we would welcome that. Thank you very much. You have worked very hard and some concrete things have come out of this. I will turn it over to Tom Horan

CONFERENCE SUMMARY

Tom Horan The Institute of Public Policy, George Mason University

When we first met in Asilomar two years ago and had the initial discussion about ITS and the environment, it was a very important but, in some ways, only an initial and superficial discussion. It was also very much in black and white terms. "Is ITS good for the environment?" Some say "yes." And, guess what? Some say, "no ITS is not good for the environment." I think that a recognition that these issues cannot be addressed in such simple terms has sent us down the path to this conference. As I mentioned at the beginning of the conference, the Diamond Bar conference looked at the technical aspects of an important aspect, air quality, and determined at that point that we had to revisit in a broad-based way all environmental impacts. The first major finding of this conference must be then the concept of VISION. It is clear that the initial ITS vision was necessarily incomplete. It tried to be as much of a vision as it could and encompass as much as it could, but if we have identified anything it must be that we all wonder what the technologies will be 30 years from now. Elmer Johnson taught us an important lesson about vision in his discussion of Chicago and avoiding the collision of cities and autos. Visions are meant to inspire, to create a concept, to create a set of interwoven ideas that can bring forth imaginative action. That is what his study and presentation did for us at this conference. The broadening of the constituency here has done a lot of good because with the environmental constituency comes, as represented by STPP and others, a whole host of associated thoughts about the quality of community, the quality of neighborhood life, the relationship of streets to open space. All of which Elmer Johnson laid out in his vision and which almost by definition cannot be a full part of an ITS vision.

What we see happening is that there is a lot of baggage for ITS to carry. It is a set of technologies and cannot be an entire vision. ITS as a field is appropriately adjusted to the concept that it is a toolbox. This is a more defensible vision because it plays into what is now a recognition that regional areas get to choose their own futures. Interestingly, as we start getting to the concepts of ITS as a toolbox and regional decision-making, everyone starts to feel a little more comfortable and has a point of agreement. Agreement was reached at this conference on the point that MPOs have become the designated meeting ground at the regional area where different parties can make their best case and the process will sort it out. Larry Dahms' message that, in complex transportation decision-making, the process is the product and the MPOs is that process illustrates well this concept. There is, I believe, widespread agreement that it is a good process and one that should be reinforced.

There was a good dynamic at this conference about private sector thinking, as represented by Steve Lockwood and others, to avoid killing the goose that could lay the golden egg. In other words, if you smother the anything with governmental process you might have nothing. In this conference we started to hit some higher ground and I think it comes out of a dual acceptance. The dual acceptance is a recognition that there is a market out there and there are consumers out there. There are aspects of technology that have high private benefits, a zero on the screen of public benefits and let us not waste our precious time. There is also an acceptance that once you start going to the public trough in a big way you buyome baggageIf you are going to use lots and lots of public dollars, you have to understand the multiple impacts this usage causes. That there is a price to be paid for large amounts of public sums. There is this mutual recognition that has started to occur. Although some black and white issues remain, the gradation of gray is very important and provides an area for further discussion.

We use the word "triage," which is probably not the right word, bit it helps focus on where the key areas of concern are because if the field is to be private, have strong private sector basis to it, what are those areas? The goal should be to get some concurrence across the communities and perhaps not hold that aspect hostage, while other aspects, which might have multiple implications should be dealt with. Another higher ground that has yet to reached is the models of cooperation issue. We need to recognize that, just as we need to recognize the market process, we need to recognize the democratic process. The democratic process issue is a little more difficult one. It recognizes the fact that in some instances communities agree, in some instances communities do not agree, but they do not have

to agree all the time and they do not have to disagree all the time. As we move toward cooperative public, private, environmental, social, and health organizations, we need to think in terms of being ad hoc, action-oriented, rather than a permanent and some sort of large organizational edifice.

In conclusion, I believe we have moved to a new level of debate, one with finer gradations of understandings. I appreciate, most of all, the fact that everybody was on their best behavior in terms of being constructive. The success of the conference could have been achieved in no other way.

EXPANDED SUMMARY OF CONFERENCE FINDINGS AND RECOMMENDATIONS

The purpose of the four BREAKOUT GROUPS conducted during the afternoons of both days of the Conference was to incorporate, as broadly as possible, the views, concerns, interests, and agendas of all attendees. The fact that the BREAKOUT GROUPS shared many of the findings and recommendations was not surprising. What was unique to this conference was that each group approached similar findings differently and provided a set of recommendations that incorporated the concerns and interests of a greater segment of the various communities than ever before. A detailed matrix of the findings and recommendations of the work done in the BREAKOUT GROUPS and agreed to by the Conference attendees may be found in the accompanying table. A summary of that effort provides the following key points:

- An understanding that although the transportation and the environmental communities do not now share a common vision, there was affirmation to strive for a common vision for ITS.
- The visionary effort would begin by mainstreaming environmental and other public interest groups into policy discussions.
 - Once the common vision was achieved, there must be a serious commitment to revisit the vision.
- . This revisitation would be based on continual application of the new, broad-based, public involvement techniques mandated by the Intermodal Surface Transportation Efficiency Act (ISTEA).

Any commitment to revisit the ITS vision must be accopanied by further commitment to take action. Any action taken must be based on the results of public outreach. The willingness to take concrete action based on the results of outreach must also recognize the role of regional diversities. Thus, the conference recommended that ITS deployment be based upon local and regional decisions.

The conference also identified the need to broaden the constituencies involved in the ITS planning and implementation coalition. The broadening must be viewed from the perspective of the state, regional and local governmental institutions. Resources are required to make this process sufficiently participatory. Only then will there be meaningful dialogue and a working through to the goals of a shared vision.

The broadening process must include strengthening the MPO's role and using the MPO process for implementing the early deployment programs. It must include land use, quality of life, and social and economic issues. There is a need to think creatively about forging new institutional linkages; to change the way institutions do business. The parallel side to changing institutional cultures is that of equity issues. Equity issues include attention to consumer needs, including the non-traditional consumers, the disenfranchised as part of the planning and implementation process. The issue of "equitable bias," or that every party comes to a meeting with some bias, is important. In shaping the program for the future, those biases must be represented equitably and no preference given to one over another.

Conference attendees reinforced the importance of research and analytical tools. There is too little known about the very broad-based constituency for ITS. There is a need to strengthen the capabilities of the existing research centers and take advantage of them while reaching to other research centers to supplement our capabilities for the complex modeling and analysis that are going to be needed.

Finally, it was concluded that institutional, societal, and environmental issues and considerations must be included in early deployment plans and that there had to be teeth in this requirement. It was deemed essential to avoid mistakes, even as the community builds upon its capabilities to learn more. Avoiding mistakes is only possible in an inclusive policy process that builds upon the broad constituency of both the environmental and transportation communities.

The four BREAKOUT GROUP moderators contributed immeasurably to the achievement of the Conference objectives. The unique contribution of the eight moderators is found in the synthesis of many perspectives. Immediately following the conference, moderators reviewed the findings and recommendations from their respective groups and recommended a matrix structure that is presented below. It was this contribution that made possible the detailed correlation of their findings and recommendations.

Specific Findings and Recommendations	Group A: New Strategies and Technologies	Group B: Energy and Environmental Implications	Group C: Institutional Issues	Group D: Societal Implications
Environmental and ITS communities must establish and	X			
articulate their respective visions of the intelligent				
transportation systems (ITS) future. This includes:				
Broadening mission statements to include environmental	X		X	
goals,			V	
establishing and adding performance measures,	X		X	
ensuring ITS missions include transportation and	X		X	
environment issues in setting goals and action strategies,				
• reviewing the goals and strategies often,	х		X	
MPOs including a vision for the whole region, leadership, and sustaining bottom-up participation in the process, where	Α		Λ	
appropriate,				
 adjusting the ITS mission to more accurately reflect 	X	X		
society's environmental goals and objectives, and		71		
accounting for both existing and emerging information	X			
technologies.				
2. Work toward agreement on the early implementation of	X	X		
measure that				
maximizeenvironmental benefits, while minimizing				
negatives. This includes:				
Having local government fund a local deployment plan and build from it,	X	X		
funding several local efforts to see how NEPA might	X	X		
interact with attempts to deploy ITS technologies, and				
providing Early Deployment Program grants directly to	X		X	
MPOS				
3. Methodologies to evaluate ITS and to be able to compare,	X		X	
according to those measures, different technologies against				
others require common measures of effectiveness. The				
Federal government should:	X		v	
• provide guidance for evaluations of IVHS implementation for early deployment that will be accepted, and	Λ		X	
undertake long-range planning that considers alternative			X	
scenarios based on investment studies that are called for			11	
under the four ISTBA management information systems.				
mandate the adoption of ISTEA legislation at the state				
level.				

Specific Findings and Recommendations	Group A: New Strategies and Technologies	Group B: Energy and Environmental Implications	Group C: Institutional Issues	Group D: Societal Implications
4. Improve research and data regarding benefits and costs	X			
associated with ITS so as to allow improved public policy	Λ			
decision-making. This includes:				
• Establishing cost effectiveness protocols for determining cost effectiveness,	X			
USDOT organizing and making available "lessons learned"	X		X	
at the State and MPO level to all States and MPOs,				
USDOT providing funding for "Centers of Excellence" to	X		X	
conduct research on institutional issues pertaining to				
transportation and the environment,	v	v		
identifying and exploring the usefulness of various analytical techniques to understand views and preferences of	X	X		
public and other stakeholder groups,				
encouraging USDOT to continue improvements in	X	X		
modeling and data collection,	A	21		
developing complex modeling techniques that include	X			X
economic, societal, racial, and ethnic groups and link land				
use, transportation and ITS,				
making a better effort to understand what the user wants				X
out of the transportation system, and				
establishing more and better fora to share information on	X			
available analytical tools, i.e.an electronic BBS that describes				
available models.				
5. Multi-modalism and inter-modalism should be part of	X		X	
intelligenttransportationsystems.				
6. Make more effective use of currently available resources				
and capabilities. This includes:				
tying togetber USDOT field personnel, IVHSA regional	X			
and student chapters in a more effective outreach effort,				
• providing, in cooperation with state governments, unified	X		X	
guidance on training and technical assistance,				
• expanding direct federal assistance to include community-	X		X	
based organizations, in addition to MPOs,.				
USDOT funding local efforts to examine ways effective	X	X		
bundling of technology applications to maximize				
environmental or maximize benefits overall, and				
7. Broaden ITS coalitions and develop institutional linkages.	X		X	
This includes:			·-	
Seeking ways for diverse groups to communicate,			X	X
attending to active planning with public involvement as a			X	X
necessary condition for institutional change,				

Specific Findings and Recommendations	Group A: New Strategies and Technologies	Group B: Energy and Environmental Implications	Group C: Institutional Issues	Group D: Societal Implications
• identifying and pursuing strategies for institutional "culture change" that influence the norms, understandings, and expectations of institutional actors consistent with shared			X	x
transportation and environmental goals, • pursuing policy actions that recognize substantial geographic variation in ITS institutions and require different institutional policy approaches in different places and at various organizational levels,			X	X
 creating task groups that include the environmental community, and 			X	X
• seeking to create a demand for systems that are sensitive to transportation and environmental needs through the use of			X	X
 marketing strategies that encourage institutional change, and making contracting procedures more flexible to encourage the consideration of local contractors. 			X	
 8. An educational initiative is required. This includes: Establishing a common language for the environmental and transportation communities, 	X		X	
Targeting local community involvement through dissemination of technical information and guidance for MPO and other local/regional staffs in environmental and planningareas,			X	
 adding user participation at the front end in the way we now have evaluation at the end of a particular project, 				X
 converting ITS into language that has meaning to the citizen using the transportation system and the MPOs, and 				X
having M-IS America encourage local level participation in M-IS America through incentives for membership. Federal funds should be directed to local entities to encourage this broader participation			X	
9. Alternative fuel vehicles work needs to be integrated or coordinated with ITS work	X			

Authors' Roundtable

I. New Strategies and Technologies

ATHENA An Advanced Public Transportation / Public Information System

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EXECUTIVE SUMMARY

ATHENA is an IVHS/NII-based "smart community" system. It is designed to be a user-friendly, taxpayer-friendly and environment-friendly way to:

reduce traffic congestion, gasoline consumption, air pollution and mobility problems, and increase business, employment, education, recreation and other opportunities

for residents of urban, suburban and rural communities. Since it employs advanced communications and computer technologies to improve the transportation of people and goods, ATHENA is an Intelligent Vehicle-Highway Systems (IVHS) or "smart cars, smart highways" project. Since it employs advanced communications and computer technologies to improve access to information and information-based services, ATHENA is a National Information Infrastructure (NII) or "information superhighway" project.

ATHENA uses telephone-based information systems to create new types of on-call transportation services (e.g. smart jitneys, taxi-like carpools) that can provide guaranteed seating and door-to-door delivery at a low cost, even in low-density areas. ATHENA uses telephone-based information systems and other computer and communications technologies to integrate these new personalized transportation services with conventional transit, paratransit and ridesharing modes to develop more cost-effective public transportation systems. Market research studies indicate that this IVHS-based approach can reduce "cold starts" and vehicle miles traveled (VMT) per capita in U.S. metropolitan areas significantly, particularly during peak commuting hours.

The interactive computer system used by ATHENA to provide drivers and riders with the capability to quickly and easily find the best ways to get between any two points in the region- in light of the latest information about the weather, traffic congestion, transit accidents, construction projects and other conditions - will also be used to provide a wide variety of other personalized public information services. These include home-shopping, telebanking, electronic mail, auto-instructional training courses, video games, stock and bond prices, sports scores and reservations for trains, buses, restaurants and parking spaces. These and other new NII-based information services will not only reduce the need for some vehicle trips and VMTs per capita, they will also generate revenues from users and advertisers to help operate and maintain ATHENA.

The City of Ontario and its public and private partners are planning to conduct a comprehensive test of ATHENA in Southern California during the next five years. The purpose of this operational test is to measure how cost-effective ATHENA is in reducing transportation, energy and environmental problems and in improving the quality of life of residents and workers in suburban communities. The multi-county test area provides homes and jobs to people with a wide range of income levels and ethnic backgrounds. The test area also has some of the worst traffic congestion, air pollution and unemployment problems in Southern California and, therefore, in the United States.

JAUNT, one of the outstanding specialized and rural public transportation providers in the United States, and its public and private partners are planning to conduct an operational test of the demand-responsive transportation elements of ATHENA in and around Charlottesville in Central Virginia during the next three years. JAUNT is also the regional ridesharing agency for the five-county Thomas Jefferson Planning District. The primary objective of JAUNT's ODYSSEY project is to find out if a small fleet of "smart jitneys" can be used to create and maintain a large fleet of "taxi-like carpools" and significantly improve the cost-effectiveness of public transportation services in small cities and in rural areas.

If the IVHS operational tests of ATHENA are as successful as projected, similar systems can be set up quickly throughout the United States. Just as a small tax on basic telephone bills now finance many 9- 1- 1 emergency vehicle information systems, a small tax on gasoline sales could finance ATHENA-like "smart community" systems in the future. Just as the Electronic Telephone Directory System was the foundation of the French "Minitel" System, ATHENA-like "smart community" systems could be the foundation for the U.S. "Information Superhighway" Program.

BACKGROUND

The wasted time and wasted fuel from traffic congestion now cost U.S. residents more than \$100 BILLION per year. The medical problems from gasoline pollution now cost U.S. residents an additional \$50 BILLION per year. However, efforts to get more Americans to use transit and ridesharing since the late 1970s have been costly and ineffective.

For example, dividing the increase in annual transit subsidies by the increase in annual transit ridership in the U.S. since 1980 shows that each additional one-way passenger trip on transit has cost taxpayers more than \$10 (in 1994 dollars) in capital and operating subsidies. Each additional commuter automobile that transit has been able to take off the road in the U.S. since 1980, therefore, has cost taxpayers more than \$5.000 (in 1994 dollars) per year in increased subsidies. In some metropolitan areas, the cost to taxpayers has been much higher than this.

Although federal, state and local taxpayers in the U.S. have spent billions of dollars a year since 1980 to encourage greater use of multi-occupant vehicles (MOVs), both transit and ridesharing have continued to lose market share to single-occupant vehicles (SOVs). According to the latest Census Bureau data, the percentage of motor vehicle commuters who used MOVs declined from 29 percent in 1980 to 20 percent in 1990. Data collected in several metropolitan areas show that the use of MOVs is still declining throughout the United States.

There are many reasons for the decline of transit and ridesharing in U.S. metropolitan areas. Three of the most important are:

- 1. Automobile users, particularly SOV drivers during peak commuting hours, are heavily subsidized. Gasoline taxes and automobile registration fees cover only a portion of the costs of building, operating and maintaining the highway-road-street network and cover none of the costs of the traffic congestion delays, air pollution and other problems caused by SOV users.
- 2. Transit has become more costly for users as well as for taxpayers. Fares and subsidies per passenger trip have increased 60 percent and 130 percent faster than inflation since 1965, respectively, while the cost of operating automobiles has declined in real terms.
- 3. Most of the population and employment growth in U.S. metropolitan areas is occurring in the suburbs. In fact, more than half of all U.S. metropolitan area workers now have jobs in the suburbs and almost 90 percent of these workers also live in the suburbs.

The June 1992 National Housing Survey by pollster Peter Hart found that "80 percent of all Americans identify the traditional single-family detached home with a yard is the ideal place to live." ^{1A} It appears, therefore, that there will be pressures to continue the suburbanization trends of the past few decades into the future. Data collected by the American Public Transit Association (APTA) show that buses operated in low-density areas have operating costs per passenger trip that are 50 percent higher than buses operated in urban areas. ^{1B} A study by Barton-Aschman Associates ^{1C} found that sixty percent (60%) of Americans will not walk more than one-eighth mile (i.e. the length of two football fields) to a bus stop. It is very difficult, therefore, for U.S. transit agencies to obtain the funds to provide frequent and convenient bus, rail or paratransit services in low-density suburban areas.

Tables 1, 2 and 3 were prepared to help those who are concerned with either government spending or with quality-of-life issues to understand what suburbanization has done to the use of conventional public transportation and conventional ridesharing. This background information is important in evaluating the cost-effectiveness of new approaches to reduce traffic congestion, gasoline consumption, air pollution and mobility problems in the U.S.

Tables 1, 2 and 3 divide the journey-to-work trips of U.S. metropolitan areas (aka SMSAs) into four mutually exclusive commuting groups - those who live and work (1) within the central city and (2) within the suburbs, and those who commute (3) between the suburbs and the central city and (4) between the central city and the suburbs. This market segmentation strategy was originally developed by Dr. Phillip Fulton of the Census Bureau and refined by transportation consultant and author Alan Pisarski to analyze journey-to-work flows in U.S. metropolitan areas.

Table 1 provides important information about the variations in the use of public transportation and ridesharing in each market segment. For example, it shows that those who live and work in the central city use public transportation much more (18.2%) than those who live and work in the suburbs (1.8%). This is not surprising since quality public transportation services are difficult to find within lower-density suburban areas and it is more costly for users to park automobiles near work sites in higher-density central cities. The large difference in public transportation use between suburb-to-suburb commuters and central city-to-central city commuters is a direct result of rational consumers examining the pros and cons of the transportation alternatives available to them today and selecting the alternatives they find most attractive.

Table 1 also shows that those who live in the suburbs and work in the central city tend to use public transportation slightly more (8.1%) than those who live in the central city and work in the suburbs (5.8%), but significantly less than those who live and work in the central city (18.2%). Again, this is not surprising because it is more difficult to find quality public transportation for those who commute to and from the suburbs than for those who commute within the central city. Public transportation services for commuters to and from the suburbs usually require higher subsidies because the trips are longer and the passenger loads are highly peaked and highly directional. As Table 3 shows, three times as many suburban residents commute into the city as city residents commute into the suburbs. It is difficult to manage transportation resources efficiently under these conditions.

One of the facts presented in Table 1 that surprises many transit advocates is that commuters in U.S. metropolitan areas prefer carpools and vanpools (20.1%) to buses and trains (8.8%). As might be expected, suburb-to-suburb commuters use ridesharing modes much more (20.0%) than they use public transportation (1.8%). However, the fact that central city-to-central city commuters use lightly-subsidized ridesharing modes as much as they use heavily-subsidized public transportation modes is usually not expected. There is a lesson here for public transportation advocates about the importance of door-to-door service and guaranteed seating to attract suburban residents out of their automobiles, station wagons and vans.

Table 1

The Means of Transportation for Each Type of Motorized Journey-to-Work Trip
By Workers Who Lived and Worked in SMSAs in 1980

Type of Commuter Work Trip		Percent of Workers For Each Type			
Place of Residence	Place of Employment	Drive Alone	Ride Share	Public Trans	Total
Central City	Central City	63.4%	18.4%	18.2%	100.0%
Central City	Suburbs	7 1.4%	22.8%	5.8%	100.0%
Suburbs	Central City	69.3%	22.6%	8.1%	100.0%
Suburbs	Suburbs	78.2%	20.0%	1.8%	100.0%
1980	SMSA Average	71.1%	20.1%	8.8%	100.0%
Projected 1990	SMSA Average	79.6%	13.2%	7.2%	100.0%

A cursory examination of Table 1 would lead one to conclude that suburb-to-suburb commuters use carpools and vanpools more than central city-to-central city commuters. Although this is true if one measures the rates of ridesharing of all motor vehicle commuters, it is not true if one measures the rates of ridesharing of all non-transit motor vehicle commuters. Table 2, which was derived from the data in Table 1, shows that among workers who commute by private vehicle, ridesharing is more popular among those who live and work in the central city (22.5%) than it is among those who live and work in the suburbs (20.4%) where employee parking is usually free and where it is difficult for carpoolers and vanpoolers to find attractive backup public transportation services.

Table 2
Rates of Ridesharing Use for Each Type of Motorized Journey-to-Work Trip
By Workers Who Lived and Worked in SMSAs in 1980

Type of Commuter Work Trip				
Place of Residence	Place of Employment	Percent of Non Transit Motor Vehicle Commuters Who Rideshare	Percent of Non-Ridesharing Motor Vehicle Commuters Who Use Public Transit	
Central City	Central City	22.5%	22.3%	
Central City	Suburbs	24.2%	7.5%	
Suburb	Central City	24.6%	10.5%	
Suburb	Suburb	20.4%	2.3%	
1980 SMSA Average		22.0%	11 .0%	
Projected 1990 SM	MSA Average	14.2%	8.3%	

Table 2 also shows that public transportation continues to be much more popular for commuters who live and work in the central city and don't rideshare (22.3%) than for commuters who live and work in the suburbs (2.3%) and don't rideshare. It is unfortunate that it was not possible to obtain segmented journey-to-work data from the 1990 census for Tables 1, 2 and 3. The unsegmented 1990 data shows significant declines in public transportation's share of commuting trips and even more significant declines in ridesharing's share of commuting trips in U.S. metropolitan areas since 1980. Although no surprises are anticipated, it would be interesting to examine the changes in market share for each of the four commuting groups since 1980.

Table 3
Change in Journey-To-Work Trips by Workers Who Live and Work
Within SMSAs With a Population of 250,000 or More (1960-1990)

Type of Journey-To-Work		Percent of Workers			
Place of Residence	Place of Employment	1960	1970	1980	1990 Projected
Central City	Central City	47.2%	37.6%	3 1.7%	27.0%
Central City	Suburbs	5.2%	7.5%	6.6%	6.0%
Suburbs	Central City	17.1%	18.6%	19.8%	20.0%
Suburbs	Suburbs	30.5%	36.3%	41.9%	47.0%
	TOTAL SMSA	100.0%	100.0%	100.0%	100.0%

Table 3 traces the changes in the relative size of each of the four U.S. metropolitan area commuting groups between 1960 and 1990. It shows that more than half (53%) of all jobs in U.S. metropolitan areas are now located in the suburbs, up from 35.7 percent in 1960, and that almost 90 percent of all these suburban jobs are filled by suburban residents. Table 2 also shows that more than two-thirds (67%) of all U.S. metropolitan area workers now live in the suburbs, up from 47.6 percent in 1960, and that less than 30 percent now commute into the central city. After examining the suburbanization trends of recent decades, it should not be surprising that the use of public transportation and ridesharing has declined and that traffic congestion has increased in U.S. metropolitan areas. It should also not be surprising that the productivity of the U.S. transit industry has declined, in terms of passenger trips per vehicle mile, and that transit fares and transit subsidies per passenger trip have risen much faster than inflation in U.S. metropolitan areas. References 2-4 discuss these cost and subsidy issues in more detail.

STATEMENT OF THE PROBLEM

By any yardstick, U.S. metropolitan areas are still losing their battles against traffic congestion, and the efforts to reduce our dependence on imported oil and to reduce motor vehicle-generated air pollution are going much slower than hoped. Table 4, which uses data obtained from the U.S. Census Bureau, shows that 3.8 million fewer workers used multi-occupant vehicles (MOVs) for commuting in 1990 than in 1980, even though the work force increased by 18.5 million during this same period. The evidence is mounting that these trends are continuing into the 1990s.

Table 4
Means of Transportation to Work in the U.S.: 1990 and 1980

	1990 Census		1980 Census		
	Number	Percent	Number	Percent	
Drive Alone	84,215,298	73.2%	6,2193,449	64.4%	
Ride Share	15,377.634	13.4%	19.065,047	19.7%	
Public Transportation	6,069,589	5.3%	6.175,061	6.4%	
Other	9,407,753	8.1%	9,183,739	9.5%	
Totals	115,070,274	100.0%	96,617,296	100.0%	

The evidence is also mounting that driving a single-occupant vehicle to a park-and-ride lot to take a bus, train, carpool or vanpool does little to reduce air pollution. "For a typical trip of 5 to 20 miles, approximately 50 percent of the emissions come from the cold-start stage, occurring in the first minute after the engine is started. For a seven mile trip, 90 percent of the emissions occur in the first mile." ID

"Because cold-starts generate such a significant share of the pollution for most trips, auto use reduction strategies should eventually give greater emphasis to reducing the number of vehicle trips taken, rather than simply reducing total miles traveled. For example, a 20-mile trip by a vanpool of six passengers where each rider drives to and from a park-and-ride lot would reduce miles traveled and increase average vehicle occupancy. But it would do relatively little for air pollution reduction, since each rider started and drove his or her own car to the park-and-ride lot. On the other hand, if that same vanpool picks up riders at home, it would make a significant contribution to emissions reductions". ^{1D}

Public transportation and ridesharing must become less dependent on "park-and-ride" lots and "kiss-and-ride" feeder services in suburban areas in order to reduce "cold starts" and air pollution levels.

Improved transit/paratransit/ridesharing services are a key to reducing traffic congestion and air pollution problems in suburban areas, where most metropolitan area residents now live and work. However, it does not appear that any mix of conventional transit, paratransit and ridesharing services will be able to provide a level of service that is attractive to residents in these low-density areas, at subsidy levels that are attractive to taxpayers. Something more is needed to solve the transportation, energy and environmental problems of suburban areas in a cost-effective manner.

Improved transit/paratransit/ridesharing services are also a key to improving the quality of life in rural areas. However, it does not appear that any mix of conventional transit, paratransit and ridesharing services will be able to provide a level of service that is attractive to residents in these low-density areas, at subsidy levels that are attractive to taxpayers. Something more is needed to solve the transportation, energy and environmental problems of suburban areas in a cost-effective manner.

"Although the drama of inner city poverty walks away with the headlines, poverty in the countryside, particularly among the working poor, is becoming more acute," according to a study by Center on Budget and Policy Priorities, a non-partisan, non-profit research group. "Nearly one in three of all hourly-paid rural workers earn at or near the minimum wage." ^{2A}

"Though the Census Bureau reports the population of Farm Belt states is up, only 4.9 million (7.6%) of the 64 million people (approximately 25 percent of the population) live in the USA's 2,400 rural counties, but nearly 500,000 of them are leaving annually"... "The million who abandoned small towns have moved into urban areas, increasing traffic congestion, air pollution and other problems there. Rural towns have to provide a reason to stay. We don't just want to preserve rural areas for people to drive to on weekends." ^{2B}

The United Sates must develop new ways to give rural area residents - particularly those who do not drive because they are too young, too old, too poor or too disabled - better access to people, goods, services and information available to urban area residents.

GENERAL METHOD OF APPROACH

Over the years, many transportation experts have pointed out that the traffic congestion, gasoline consumption, air pollution and parking problems of the U.S. are not caused by a shortage of transportation resources. Most areas in the U.S. have enough transit vehicles and automobiles to handle their existing travel demands, using only the front seats of the automobiles. Most areas also have enough roadways and parking to handle all these multi-occupant vehicles without traffic congestion.

Most areas of the U.S. also have enough automobiles and other transportation resources to provide good public transportation services for all their existing residents, including he poor, the aged and the disabled. The transportation-related problems of the U.S. are largely the result of not having information systems that will permit decision-makers to manage their existing transportation resources effectively, particularly in low-density suburban and rural areas.

The following section discusses the French "Minitel" System, German "Smart Bus" Systems, and the California "Smart Traveler" System. These three innovative information systems provide insights into possible ways to use new technologies to reduce traffic congestion, gasoline consumption, air pollution and mobility problems in the United States. The following section also discusses The ATHENA System.

DISCUSSION

The French "Minitel" System

During the 1980s the government-owned telephone company in France distributed small, low-cost, black-and-white computer terminals (called Minitels) to millions of homes and offices instead of printed telephone books. Using a Minitel terminal, connected to the telephone line, anyone could find the current listed phone number of any

person or business in France. Unlike the printed phone book, the "Minitel Electronic Directory" is always up to date. As a result of this system, the telephone company received fewer requests for information and directory service personnel could be transferred to other activities.

Since most Minitel terminals are only used a few minutes a month for directory information, the telephone company invited other government agencies and the private sector to provide other telephone-based, videotex information services (e.g. home banking, teleshoppingelectronic mail, video games) to Minitel owners for a fee. Today, there are more than 10,000 information services available to Minitel users and they generate millions of dollars in revenue to the telephone company from advertisers, users and fees for centralized billing and collection services. They also provide jobs.

Although the graphics and the technologies are primitive by today's PC standards, the Minitel videotex system is a successful National Information Infrastructure (NII) project. The Minitel system can also be viewed as a successful, public-private IVHS/Advanced Traveler Information System (ATIS) project, because users can use it to find transit schedules, check traffic conditions on the freeways, book train reservations, order taxis, etc. at any time, without operator assistance. By imbedding the ATIS functions in a multi-purpose information system, France was able to save hundreds of millions of dollars in design, development, implementation, training, marketing and administrative costs. For more information on the French Minitel System consult Reference 7.

German Smart Bus Systems

In order to increase transit ridership and reduce operating costs in suburban and rural areas, some counties in Germany have installed new transit-telecommunications systems (e.g.FOCCS) that permit residents to request "bus" rides between any two checkpoints (e.g., bus-stops) at any time. These "smart bus" systems are user-friendly. A prospective rider does not need to know the route number, the schedule of the "bus", or the fare structure. To use a "smart bus" (i.e. a "bus" equipped with an on-board computer terminal and a wireless data communications link with the central dispatching computer), a prospective rider calls an easy-to-remember telephone number. A telephone operator enters the following trip request information into a computer terminal: (1) Origin checkpoint number, (2) Destination checkpoint number, (3) Requested departure time (including ASAP), (4) Number of people traveling together, and (5) Special needs (e.g. wheelchair, seeing-eye dog, baby stroller).

The central computer matches the trip request against the available resources, and quickly dispatches the most cost-effective bus, mini-bus, or microbus (i.e. taxi) to pick-up the rider and his or her traveling companions. The telephone operator tells the passenger when to be at the checkpoint, the fare, and the number of the bus, van or automobile (i.e. taxi) that will provide the ride. The average waiting time for a passenger is less than eight minutes. Alternatively, riders can use kiosks at some major bus stops to enter trip requests directly into the FOCCS computer and bypass the telephone operator. However, the waiting time for the "smart bus" then starts at the bus stop rather than in the home, office, shop, etc. of the caller. This can be a disadvantage to users in bad weather. Furthermore, the kiosks tend to be costly to install, operate and maintain.

The FOCCS system can use any bus, mini-bus or micro-bus in fixed-route mode, route-deviation mode or demand-responsive mode, at any time of the day or night. This multi-modal transportation capability has helped to improve service and to reduce operatingcosts in low-density areas and during low-travel periods. Despite the sophistication and elegance of the FOCCS transit-telecommunications system, however, the available data suggests that the operating cost savings provided by FOCCS in Germany and Australia are barely enough to cover the costs of the additional computer and telecommunications equipment that is required. Although the FOCCS "smart bus" system is more user-friendly than traditional transit-paratransit systems, it is not more taxpayer-friendly. For more information on German "Smart Bus" Systems consult Reference 3.

California Smart Traveler (CST) System

Both the California Department of Transportation (Caltrans) and USDOT have established major IVHS programs to investigate ways that computers, telecommunications and other electronic technologies could be used to improve the cost-effectiveness of local and regional transportation systems. In the early 1990s, these organizations

jointly sponsored two "California Smart Traveler" studies to investigate how telephone-based information systems could be used to:

Develop new types of low-cost, door-to-door public transportation services.

Integrate these new services with conventional transit, paratransit and ridesharing modes to create more user-friendly and more taxpayer-friendly public transportation systems.

Provide drivers and riders with the capability to quickly and easily find the best ways to get between any two points in the region, in light of the latest information about the weather, traffic congestion, construction activities, transit accidents, etc.

The "California Smart Traveler" studies also examined a number of potential test sites and prepared cost projections for IVHS operational tests in three suburban communities in the State.

Caltrans, USDOT, Tri-Met (Oregon's largest transit agency) and others have been studying FOCCS and other German "smart bus" systems to find ways to make these systems more user-friendly and more taxpayer-friendly, particularly for use in low-density areas of the United States. For example, substituting door-to-door services for checkpoint-to-checkpoint services would make the FOCCS system more user-friendly. Adding features that would reduce subsidies per passenger trip would make the FOCCS system more taxpayer-friendly.

One way to make the German FOCCS system both more user-friendly and more taxpayer-friendly is to add an interactive, multimedia, front-end computer to the central dispatching computer system. With this capability, would-be riders would be able to simulate the use of a FOCCS kiosk with a touch-tone telephone (i.e. audiotex), personal computer (i.e. videotex) or some other input/output (I/O) device. The front-end computer would let a would-be rider bypass telephone operators and quickly enter his or her ride request directly into the FOCCS dispatching computer by pressing one or two buttons on a touch-tone telephone, PC or other I/O device. This would make the FOCCS system more user-friendly when the telephone operators are busy. The front-end computer would also reduce the number of telephone operators required to handle a given number of ride requests each day. This would make the FOCCS system more taxpayer-friendly. The proposed California Smart Traveler System has an interactive, multimedia, front-end computer in its design.

A second way to make FOCCS more user-friendly and more taxpayer-friendly is to add new ridesharing services, The front-end computer makes it possible to develop single-trip carpool matching capabilities. A would-be rider would be able to request a ride (e.g. between home and school) by merely pressing one or two keys on atouchtone telephone, PC or some other I/O device. The detailed specifications (e.g. origin address, destination address) for the trip will be pre-stored in a computer file. A would-be driver would be able to offer a ride (e.g. between work and home or points in-between) by merely pressing one or two keys on a touch-tone telephone, PC or some other I/O device. The central dispatching computer would try to match them with other ride offers and ride requests. This is a way to provide low-cost, door-to-door transportation services to residents of low-density suburban and rural areas and to provide part-time work for single-trip carpool drivers. The proposed California "Smart Traveler" System also has single-trip carpool matching capabilities in its design.

The following two subsections outline the process for requesting and offering single-trip or taxi-like carp001 (TLC) rides in the California Smart Traveler (CST) System:

Requesting A Single-Trip Carpool Ride

An individual desiring to obtain a single-trip catpool ride would make a telephone call to the local ride-request number. The would-be rider would provide his or her travel itinerary, including date-time, origin, destination and number of seats required. The information would also include any specific restrictions or preferences (e.g. no smoking, no radio). The CST computer system would then search through the database of active information about the make and color of the vehicle, license number, driver's name or ID number, telephone number, scheduled pick-up time, etc. Although this is not a requirement, the would-be rider could call the would-be driver to confirm the match and to "iron-out" any other details.

If no match is found, the would-be rider would be told about the availability of other public transportation services for his or her trip or would be asked to call back at a scheduled time to see if a match could be found. In the latter case, the would-be rider's request would be added to a database of active single-trip carpool ride requests. The CST computer system would continue to analyze new ride offers to look for a match until the scheduled callback time. Alternatively, the CST computer could notify the would-be rider via a paging service as soon as a match was found. In the future, would-be riders who own micro-cellular Personal Communications Network (PCN) phones or Personal Digital Assistants (PDAs) could be "called" as soon as a match was found and provided with the match details.

Offering A Single-Trip Carpool Ride

An individual desiring to offer a single-trip carpool ride would make a telephone call to the local ride-offer number. The would-be driver would provide his or her travel itinerary, including date-time, origin, destination and number of seats available. The information would also include any specific restrictions or preferences. The CST computer system would then search through the database of active single-trip requests for a match. If a match is found, the would-be driver would receive information about the location of the pick-up point, riders name or ID number, scheduled pick-up time, etc. Although this is not a requirement, the would-be driver could call the would-be rider to confirm the match and to "iron-out" any other details.

If no match is found, the would-be driver would be asked to call back at a scheduled time to see if a match could be found. In this case, the would-be driver's offer would be added to a database of active single-trip carpool ride offers. The CST computer system would continue to look for a match until the scheduled call-back time. Alternatively, the CST computer could contact the would-be driver via a paging service as soon as a match was found. In the future, would-be drivers who own PCN phones or PDA devices or whose vehicles are equipped with cellular phones could be "called" in their vehicles. The ability to contact a would-be driver enroute to his or her destination would increase the likelihood of finding a would-be rider.

Another way to make the German FOCCS system more user-friendly is to add driver information services. Connecting the multimedia front-end computer to a regional Traffic Operations Center's (TOC's) computer system would permit drivers to get more timely and more accurate information about the status of the regional roadway network in the future. By pressing one or two keys on a PC or a telephone, a driver of a taxi, truck, shuttle or private automobile would be able to quickly find out if his or her planned route is experiencing unusual traffic delays and, if so, to find the best alternative route. This personalized traveler information service would be particularly useful during commuting hours and during storms. The proposed California "Smart Traveler" System is being designed to provide personalized traveler information services in the future. The ATHENA System is an enhanced California "Smart Traveler" System, consult References 4 and 5.

The ATHENA System

USDOT and IVHS AMERICA released a draft National IVHS Program Plan which provides a blueprint for the work needed to achieve the goals and objectives stated in the IVHS Strategic Plan. The draft Program Plan focuses on IVHS services from the perspective of potential users. It identifies 27 IVHS user services and sets out a program for the development and deployment of each service over the next five years. One of these IVHS user services is the Ride Matching and Reservation user service.

The National IVHS Program Plan describes the Ride Matching and Reservation user service as a mechanism for expanding the market for shared-ride transportation by providing real-time ridematching information, along with reservations and vehicle assignment, and by serving as a clearing house for financial transactions. According to the program plan, these capabilities will not only expand the market for ridesharing as an alternative to single-occupant vehicles (SOVs), they will also provide enhanced alternatives for special population groups. For example, "Human services agencies (could) benefit from this user service by having access to broader transportation service options with reduced administrative overhead."

Although the National IVHS Program Plan notes the success of low-technology single-trip ridematching systems (i.e. "slug lines" or "instant/casual carpools") for the Shirley Highway Corridor in Washington D.C. and the Bay Bridge Corridor in the San Francisco Bay Area. it does not mention that these are very special situations. Both of these corridors have attractive incentives for using MOVs rather than SOVs, dependable public transportation services for backup, and there are "enough" drivers and riders traveling in the same direction at the same time. Nor does the Program Plan mention that there are few, if any, successful single-trip carpool operations in other high-volume travel corridors in the United States and there are no successful single-trip car-pool operations in any low-volume travel corridors in the United States.

It will be difficult to establish successful single-trip carpool systems in low-density suburban and rural areas. One reason is the costs of providing attractive backup with either conventional or "smart" transit-paratransit modes will be very high. A second reason is it will be difficult to attract drivers before there are riders and riders before there are drivers. This is the "chicken-and-egg"problem of single-trip ridesharing. A third reason is the problem of sustaining rider and driver interest if the match rate is low for single-trip carpools. This low match rate for conventional ridesharing services is major metropolitan areas (e.g. Washington D.C., Los Angeles) suggests that it will be difficult to maintain a "critical mass" of drivers and riders in low-density areas.

The ATHENA System contains enhancements to the proposed California Smart Traveler System that address both the "chicken-and-egg" and the "critical mass" problems for single-trip ridesharing in low-density areas. One enhancement is the use of "smart jitneys" to provide dependable and low-cost backup services for single-trip car-pools. "Smart jitneys" (e.g. usually 8-12 passenger vans) will be equipped with personal digital assistants (PDAs). These devices will enable a small fleet of "smart jitneys" to provide flexible-route, personalized MOV transportation services in corridors where conventional public transportation services would not be cost effective.

Most "smart jitneys" will be owned or leased by drivers who regularly make long trips on the same routes (e.g. home to work, school to home) in the region. Workers, students and others who drive "smart jitneys" will be told by their on-board PDA when and where to deviate from their regular routes to pick up and deliver passengers enroute. These "smart jitney" drivers will be paid a minimum each month (e.g. \$400) for spending on the order of one hour per day, five days a week, providing personalized MOV transportation services on their way to and from work, school, etc.

When a "smart jitney" gets to a pick-up point, the driver will use the on-board communications equipment to advise the ATHENA dispatching computer if the passenger was on-board or a "no show". The on-board PDA will then tell the driver the location of the next stop to pick up or deliver passengers. In the future, GPS receivers may be added to the "smart jitneys" to provide automatic vehicle location (AVL) capabilities that can be used to check if the "smart jitney" driver was at the right place at the right time. This AVL capability should improve the quality of transportation services for "smart jitney" riders and provide an extra measure of security for both "smart jitney" drivers and riders.

If a typical "smart jitney" driver spends 15 minutes picking up riders in his or her origin neighborhood and another 15 minutes delivering riders in his or her destination neighborhood, the average delay time and the maximum delay time for a smart jitney rider will be 15 minutes and 30 minutes, respectively. Although these delays in door-to-door travel time may be acceptable to some riders, many riders would rather save this time by driving alone. These time-sensitive riders will be able to eliminate or greatly reduce travel-time delays by using single-trip carpools most of the time. Single-trip carpools, which need not be equipped with "smart" equipment (i.e. PDAs), will only pick up one passenger group per trip and will deliver the group to its destination without intermediate stops. The single-trip carpool driver will get the name and address of the passenger over a telephone, usually before starting out. However, single-trip carpool vehicles that are equipped with cellular phones or PDA terminals can obtain this information enroute.

Although ATHENA's "smart jitneys" are expected to be more "taxpayer friendly" than fixed-route buses or dial-a-ride minibuses in low-density rural and suburban areas, they will still need to be subsidized. Consequently, the fleet of "smart jitneys" in the area will be small and their primary mission will be to complement and supplement a much larger fleet of very low subsidy vehicles (e.g. single-trip carpools, taxi-like carpools (TLCs), voice-dispatched

jitneys, parataxis). Since these very low-subsidy vehicles will not require on-board PDA terminals or other computer/telecommunications equipment, they can be added to regional fleet of ATHENA public transportation vehicles quickly, and at a low-cost to taxpayers.

The interactive computer network that is used by ATHENA to process ride offers and ride requests, to dispatch and monitor vehicles, and to collect and disburse "fares", will also be used to provide a wide variety of personalized information services to travelers in the future. By merely pressing one or two keys on a touch-tone telephone, cellular phone, personal computer, multi-media kiosk, personal digital assistant (PDA), etc., drivers and riders will be able to find the best ways to get between any two points in the region in light of the latest information on weather conditions, traffic conditions, transit accidents, construction activities and others.

Advertisers who sponsor these pre-trip or en-route traveler information services and new types of traveler services information (e.g. electronic Yellow Pages) will keep the cost of ATHENA low to both users and taxpayers. Like the Minitel system in France, the ATHENA system will also encourage government agencies and private organizations to utilize its telephone-based computer network to provide a wide range of new information services (e.g. home shopping, telebanking, electronic mail, video games, auto-instructional training courses) to community residents.

France has spent 15 years and over \$2 billion (in 1994 dollars) to develop a multi-purpose, telephone-based information system. The French Minitel system has created many new business, employment, education and other opportunities for residents of urban, suburban and rural areas. Users and advertisers now pay all of the costs of operating and maintaining the nationwide French system. ATHENA will take full advantage of the lessons learned by operators of the Minitel system and other videotex information systems (e.g. Prodigy, CompuServe).

Moreover, ATHENA plans to use touch-tone telephones, as well as personal computers (PCs) and videotex terminals, to provide access to ATHENA's wide range of information services. This will not only cost much less than the French approach to get it started, it will also save time in establishing a critical mass of users who are ready to use ATHENA's driver, rider and other information services.

CONCLUSION

Intelligent Vehicle-Highway Systems (IVHS) technologies can be used to develop new types of public transportation services (e.g. "smart jitneys", taxi-like car-pools) and to integrate these new services with conventional transit, paratransit and ridesharingmodes to form multimodal Advanced Public Transportation Systems (APTS). Preliminary market research studies indicate that APTS can significantly reduce traffic congestion, gasoline consumption, air pollution and mobility problems at a low cost to taxpayers.

A user-friendly Advanced Traveler Information System (ATIS) is a critical component of a well-designed APTS. By pressing one or two buttons on a touch-tone telephone, personal computer (PC), videotex terminal or other input/output device, a "smart traveler" will be able to quickly find the best ways to get between two points by public transportation. These public transportation vehicles can be either privately-owned or publicly-owned ferries, trains, buses, minibuses, vans or automobiles. Their drivers, like the drivers of some rural fire departments, can be full-time, part-time, piece-work, or volunteers.

A user-friendly ATIS system is also an important partner for a well-designed Advanced Traffic Management System (ATMS). By pressing one or two buttons on an input/output device, a "smart traveler" will be able to quickly find the best routes to take to drive between two points, based on the latest information about accidents, construction projects, weather, etc. Integrating ATIS with other audiotex or videotex information services (e.g. home-shopping, telebanking, electronic mail, video games, interactive training programs) could reduce the need for some trips and VMTs per capita, as well as the cost of the ATIS services.

ATHENA has been designed to help urban, suburban and rural communities use their existing telephone systems to:

make more efficient and effective use of their existing public and private transportation resources, increase the mobility of all residents, including the poor, the aged and those with disabilities, reduce traffic congestion, air pollution and parking problems, control spending at all levels of government, reduce oil imports and improve the U.S. balance of trade, and create new transportation service jobs, information service jobs, and other jobs for local residents.

If the IVHS operational tests of ATHENA are as successful as projected, similar systems can be set up quickly throughout the United States. Just as a small tax on basic telephone bills now finance many 9-1-l emergency vehicle information systems, a small tax on gasoline sales could finance ATHENA-like "smart community" systems in the future. Just as the Electronic Telephone Directory System was the foundation of the French "Minitel" System, ATHENA-like "smart community" systems could be the foundation for the U.S. "Information Superhighway" Program.

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A LEAST TOTAL COST APPROACH TO COMPARE IVHS, LAND USE, MANAGEMENT AND MULTI-MODAL INFRASTRUCTURE ALTERNATIVES

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WHY A LEAST TOTAL COST APPROACH?

The new environment for transportation planning in the 1990s presents a challenge to planners and decision makers in evaluating multimodal alternatives. The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 provides new intermodal funding flexibility. Also, ISTEA requires consideration of efficiency, social, economic and environmental factors in the evaluation process. The Act's emphasis on "management" calls for development of procedures that allow comparisons across a variety of alternatives including new services, land use and demand management as well as high capital investment-type solutions. Additionally, the Clean Air Act Amendments (CAAA) of 1990 emphasize vehicular demand management as an important strategy to reduce air pollutant emissions. Future evaluation procedures will thus need to: (a) give adequate consideration to economic efficiency and social and environmental impacts; and (b) be capable of allowing comparisons across modes as well as across a variety of high capital and low capital or management strategies.

In the past, Metropolitan Planning Organizations (MPOs) have usually compared transportation projects using measures of effectiveness which are uniquely applicable to a specific mode. For example, measures of highway project effectiveness commonly used are improvement in highway level of service (LOS) or highway speed, reduction of highway accidents or savings in highway user costs. Transit project effectiveness, on the other hand, is usually measured by transit ridership or public capital and operating costs per new rider. It is likely that Intelligent Vehicle-Highway System (IVHS) projects will also use different measures of effectiveness, depending on their modal orientation. If IVHS projects or programs benefitting different modes (e.g. highway solo-driver, highway shared ride or transit) are to be compared with one another or with other types of investment or management strategies, common measures of effectiveness will have to be used i.e. measures applicable across modes, and across supply-enhancing and demand-reducing strategies.

The least total cost approach uses a common measure (i.e. total cost) which is applicable across all types of alternatives. It attempts to account for the full costs of each alternative. The main advantages of this approach are: (1) It allows comparisons of transportation investments across modes; (2) It allows comparisons of major investment alternatives (e.g. new highway or transit capacity) with management alternatives such as new or improved services (e.g. using IVHS technology), pricing strategies, land use strategies and other strategies which moderate travel demand.

The least total cost approach facilitates accounting for costs of competing highway-oriented and transit-oriented IVHS projects in a comparable manner. For example, in current practice, when computing costs for transit alternatives, analysts include vehicle capital and operating costs and costs for garaging the vehicle. On the other hand, analysts computing the costs for highway travel may include the variable portion of vehicle operating costs such as costs for gas and oil, maintenance and tires, but exclude the fixed costs such as vehicle ownership costs and parking or garaging costs at each end of the trip. (Note that, in the long range, vehicle fixed costs and parking fixed costs are avoidable costs i.e. they are not sunk costs to be ignored). For valid comparisons across modes, the $ful\ l$ avoidable future costs of each alternative will have to be taken into account, not just costs incurred by transportation agencies for capital investment and operation. Public costs incurred by non-transportation public agencies (e.g. police, fire, court systems, etc.), fixed private costs (e.g. auto ownership costs), and external social and environmental costs cannot be ignored. From a societal point of view, it is irrelevant whether costs are borne privately, publicly or socially.

In a least total cost approach, user benefits other than satisfaction of the basic need for access, for example comfort and convenience advantages of a particular modal alternative, need not be excluded. User benefits or "amenities" can be included in the cost totals as negative costs if they are quantifiable and can be converted to monetary terms. Some user benefits and disbenefits, as well as some external costs and benefits, cannot easily be converted to monetary terms. They may be listed with some measure of their magnitudes for use in trade-off analysis. For example, a break even analysis could be done to determine how much additional benefits from a higher total cost alternative would have to be worth in dollars in order to make decision makers indifferent between the higher cost alternative and the one with the least total cost.

The base to which alternatives are compared in current practice also poses a problem. In current practice, the base used for comparison is usually a future year "do-nothing", or "no-build plus Transportation System Management (TSM)" alternative. Benefits of the alternatives are calculated based on savings with respect to the base. However, the savings estimates will not be real if the base itself could never exist in reality, which is often the case. For example, before the large delays forecasted under base conditions could ever occur, it is probable that travelers would change their travel patterns (either traveling at different times of the day, by different modes, to different destinations, or by different routes); or they may even decide not to make the trip. It is therefore probable that benefits claimed for alternatives by comparing them to the base are inflated to some extent. (Note that travelers do suffer losses in overall utility when they are compelled to shift their travel patterns; however, the increase in travel times modeled under the typical base year scenario probably overestimates their utility losses.)

The least total cost approach as applied in this paper embodies the following major features:

- 1. A comprehensive accounting is made of the full costs of the current transportation system as well as the future alternatives, to the maximum extent feasible. User benefits or external benefits in excess those for the least total cost alternative are included as negative costs for the remaining alternatives.
- 2. The effectiveness of alternatives is measured using a common measure which describes the chief "deliverable" of an urban transportation system i.e. access. The measure is person trips served, or the ability of alternatives to accommodate the future increment in demand for trips. Where policies to shift person travel demand to telecommuting, walk or bicycle modes are to be evaluated, it is assumed that walk and bicycle trips as well as "eliminated" trips from telecommuting are included in the total of trips accommodated. Each alternative is assumed to be capable of providing for the increment in demand for access, but at differing incremental cost, reducing the problem to one of finding the least total cost alternative.
- 3. Incremental costs of alternatives may be calculated relative to a real base, i.e. the existing system and its travel demand, performance and cost.
- 4. Major investment alternatives oriented to any mode can be compared. Also, they can be compared with alternatives which involve no differences in public investment, but only policy differences (e.g. land use plan and zoning changes, trip reduction ordinances, and parking surcharges).
- 5. Incremental cost per added trip may be computed by dividing the incremental costs above the current year costs by the increment of trips served above the current year trips. This measure clarifies the true costs of growth.

APPLYING THE LEAST COST APPROACH

The approach is demonstrated in this paper through application to a case study using a simplified microcomputer-based spreadsheet (LOTUS 123). The focus of the case study is on comparison of land use and IVHS strategies. A previous paper presented a case study application of the approach focusing on evaluation of major transportation investments.'

Unit costs of travel differ depending primarily on two variables: (1) time of day e.g. peak or off-peak; and (2) type of trip e.g. personal travel for work, personal travel for non-work purposes, or freight travel. These two variables can be used to categorize travel demand into six travel markets. The case study application focuses on the peak period work (person) travel market.

All costs for providing access are included in the evaluation of costs for accommodating future trips, whether or not the tripmaker bears them directly. Costs may be categorized based on whether or not they have market prices. Market-priced costs include dollar costs borne privately by system users and publicly by transportation or other agencies. Market-priced costs may be categorized as private vehicle costs, public transportation system costs, highway facility costs and safety and security costs. Costs which have no market prices include travel time costs, environmental costs, pain and suffering components of accident costs, and other social costs such as community disruption. They may be borne by system users (e.g. travel time costs) or externally (e.g. environmental costs).

Dollar value estimates of many of these costs may be found in the literature, as indicated in Table 1. However, there are other social costs for which it is unlikely that dollar values can be developed -- they will simply have to be listed with estimates of their orders of magnitude for consideration in trade-off evaluation in the decision-making process. Examples of these impacts are: national defense implications for protection of oil sources, community cohesion or disruption, community pride, aesthetics, accessibility of disadvantaged segments of the population, loss of cultural, historic, recreational and natural resources, loss of open space and depletion of non-renewable energy resources.

Cost parameters used in the application example presented in this paper are based on values shown in Table 1, with appropriate adjustments as presented in Table 3 for IVHS alternatives. The adjustments account for cost increases due to IVHS technology (both publicly and privately borne) and cost savings from reduced accidents and reduced needs for new highway lanes. More detailed methods for calculation of costs could certainly provide more accurate estimates of costs. The purpose of the example is simply to demonstrate how the approach may be used in real world situations, and not to provide definitive answers about the cost-effectiveness of the alternatives evaluated.

The basic process for computation of costs is indicated in Figure 1. The process relies heavily on output from the four-step travel demand modeling process, both for the base year condition as well as for future year alternatives. As Figure | indicates, the outputs from the travel models needed for input into the costing procedures are the following, for each person travel market: (1) person trips by mode (from mode choice); (2) travel miles (from trip assignment) by mode -- person miles of travel (PMT) on transit line-haul and transit access modes, as well as vehicle miles of travel (VMT) on the highway system; and (3) travel minutes (also from trip assignment) by mode. As Figure 1 indicates, the travel measures output from the travel models are input into cost models which provide unit cost parameters for the various cost components. Unit costs may be costs per trip, per PMT, per VMT or per minute of travel time, as indicated in Table 1.

The case study urban area was Washington, DC. A previous study 10 provided model output data. In cases where needed travel parameters were not available from the study report, national averages from the Nationwide Personal Transportation Study (NPTS) were used." The Washington, DC study involved analysis of the systemwide travel and transportation system impacts of two alternative urban development patterns for the year 2010. The first alternative (BAL) promoted a closer balance between housing and employment growth, both regionwide and within individual "employment growth" subareas within the region. The second alternative (CONC) maintained regionwide balance between housing and employment as in the first alternative, but concentrated employment in areas with good transit service and significant levels of transit use at the job end of the work trip. The study also provided a base model run for 1995. To demonstrate the application of the least total cost approach with IVHS alternatives, two new alternatives were developed by the author. Both built upon the concentrated (CONC) alternative. The first alternative, IVHS(S), assumed use of only supply-enhancing IVHS technologies such as technologies which smooth the flow of highway traffic, provide priority to transit vehicles, provide real-time information to highway and transit users, provide new services e.g. single-trip cat-pooling, and enhance highway and transit safety. The second alternative, IVHS(D), added to IVHS(S) by managing demand through pricing mechanisms for peak use ofhighways.

The travel data and results of the cost analysis are presented in Table 2. A comparison of total costs which were calculated by the spreadsheet suggests that the concentrated (CONC) alternative has lower total costs than the balanced alternative (BAL). Based on the liberal use of cost and travel demand assumptions for IVHS by the author, the IVHS(S) scenario could save about \$400,000 daily in aggregate mobility costs relative to the concentrated (CONC) scenario. For the IVHS(D) scenario, the savings would be about \$5.7 million daily. Public agency costs (for highways and for public transportation deficits assuming a 40% farebox recovery rate) would be about \$244,000 lower daily under IVHS(S) and \$3.4 million lower daily under IVHS(D) As indicated earlier, the cost totals include only those cost items included in Table 1, and exclude some non-monetizable environmental and social costs. Many of these costs are primarily related to auto travel. Since the IVHS(D) scenario involves much less auto travel than the other scenarios, additional savings in non-monetizable environmental and social costs may be expected.

Table 2 also indicates that, while providing mobility currently costs about \$5.90 per work trip (including all cost items listed in Table 1), the cost per new trip added by 2010 will be significantly higher under all future alternatives except for IVHS(D) Average cost per added trip amounts to \$10.35 under the balanced scenario, \$10.03 under the concentrated scenario and \$9.54 under the IVHS(S) scenario, but only \$3.00 under the IVHS(D) scenario.

Note that Table 2 includes a line item for "negative costs". These are the additional user benefits for the BAL, CONC and IVHS(S) alternatives relative to the IVHS(D) alternative, reflecting primarily the consumer surplus enjoyed by single occupant vehicle (SOV) drivers who are tolled off by the IVHS(D) alternative. This consumer surplus is calculated by multiplying the number of SOV drivers tolled off by half the tolls they would have had to pay. The IVHS(D) alternative is assumed to cause shifts of SOV drivers to other modes only, since work trips are not very likely to shift out of the peak periods during which tolls apply due to limited flexibility of work start and end times. (Note that there may be some debate as to whether the consumer surplus losses suffered by tolled off SOV drivers have already been accounted for through the higher travel times on the HOV and transit modes which are included in the "positive" cost totals. The excess travel time costs incurred by SOV drivers who shift modes may need to be subtracted if their consumer surplus losses are included as negative costs. The spreadsheet has not been set up to do these calculations at this time.)

CONCLUSIONS

This paper has explained the theory in support of a least total cost approach to compare transportation investment alternatives across modes, and to compare significant changes in management and land use policies. The approach is based on assessing the relative economic efficiency of alternatives by determining which alternative involves the least total cost for providing access for various travel markets. The approach has been demonstrated through application of a simplified analysis technique using a LOTUS 123 spreadsheet. Results from the analysis have been presented *for demonstration purposes only*. The application of the approach to the case study suggests that the approach can be a useful tool for comparison of multimodal investment, IVHS, management and land use policy alternatives.

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TABLE 1

EXAMPLE UNIT COSTS

Unit Cost

	Unit Cost						
Cost Component		<u>Source</u>					
Market-Priced Costs:							
Vehicle	7.4 cents/VMT						
Operation	\$ 3.12/trip	Ref.1 (less cent fuel tax)					
Ownership	\$ 3.00/trip	Ref.1 (less acc. insurance)					
Parking Downtown	\$ 1.00/trip	Ref.1 (plus land cost)/2 trips					
Other	ψ 1.00/шр	Ref.1 (plus land cost)/2 trips					
Other		Ref.1 (plus land cost)/2 trips					
Highway	1.8 cents/VMT						
Oper. & Maint auto	2.9 cents/VMT	Ref.2					
bus	62 cents/added VMT	Ref.2, bus/car eqivalency = 1.6					
Added capacity auto	99 cents/added VMT	Ref.2, Los Angeles Plan data					
bus		Ref.2, bus/car eqivalency = 1.6					
Public Transportation	\$ 3 .00/trip						
Bus system line-haul	\$ 1.50/trip	Ref.3, in current dollars					
feeder	\$ 4.25ltrip	Ref.3. divided by 2					
Subway system	•	Ref.3, in current dollars					
J J		,					
Safety & Security	1.1 cent/VMT						
Public services auto	1.1 cent/VMT	Ref.4, in current dollars					
bus	0.22 cent/VMT	Ref.4, in current dollars					
rail	4.2 cents/VMT	Ref.4, adj. for acc.rate in Ref. 1					
Accident (market) auto	8.4 cents/VMT	Ref.7					
bus	1.68 cents/VMT	Ref.7					
rail		Ref.7 adj. for acc.rate Ref.1					
		-					
Costs With No Market Prices	A 4 70V						
The state of the s	\$ 4.50lhour	The state of the s					
<u>Travel time</u>		Estimated					
Environmental	2.4 cents/VMT						
Air pollution	0.2 cent/VMT	Ref.4, in current dollars					
Water pollution	0.16 cent/VMT	Ref. 12					
Noise	0.2 cent/VMT	Ref.4, in current dollars					
Solid/chemical waste	1.5 cent/VMT	Ref.5					
Oil extraction	4.46 cents/VMT	Ref.5					
(Subtotal)	. , , , , , , , , , , , , , , , , , , ,						
()	7.8 cents/VMT						
Accidents (non-market) auto	15.6 cents/VMT	Ref.7					
bus	3.12 cents/VMT	Ref.7					
rail		Ref.7					
		,					

TABLE 2
COSTS FOR WEEKDAY PEAK PERIOD WORK --TRAVEL

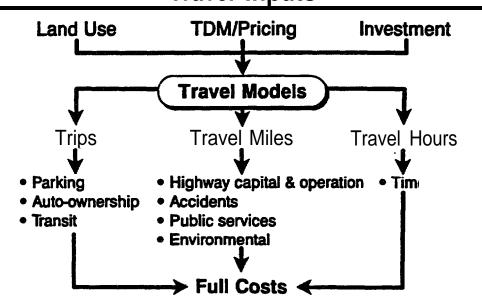
			1995 <u>BASE</u>	2010 BAL	2010 <u>CONC</u>	2010 IVHS(S)	2010 IVHS(D)	
Peak period travel data (millions per day)								
Trips:		ps person trips person trips	1.3748 0.9904 0.4599	1.9308 1.1483 0.5563	1.8749 1.1751 0.5855	1.8749 1.1751 0.5855	0.8583 2.0916 0.6855	
		erson trips chicle trips	2.825 1 1.825	3.6354 2.453	3.6355 2.409	3.6355 2.409	3.6354 1.809	
VMT:	Total (i	ncl.bus and transit access)	19.329	25.93 1	25.498	25.498	19.333	
Time:	Total (i	ncl. walk and wait time)	69.7967	88.4880	89.1946	86.2673	9 1.6269	
Peak period travel costs (dollars per day)								
Market	costs:	Auto (\$M) Transit (\$M) Total (SM)	6.883 2.106 8.989	13.408 2.560 15.968	12.964 2.697 15.662	12.956 2.696 15.651	6.738 3.166 9.904	
Non-ml	kt costs:	Time (\$M) Environmental (\$M) Accident (pain) (\$M)	5.235 0.862 1.514	6.637 1.157 2.03 1	6.690 1.137 1.997	6.470 1.137 1.831	6.872 0.862 1.392	
Total co	osts:	Total +ve costs (\$M) Negative costs (\$M) Net total costs	16.600	25.791 -0.804 24.987	25.486 -0.762 24.724	25.090 -0.762 24.328	19.030 0.000 19.030	
		Avg. net cost per trip Incr. cost per added trip	5.876	6.873 10.349	6.800 10.025	6.692 9.536	5.235 2.999	
Transp.	agency:	Total costs (\$M) Incr. cost per added trip	1.817	6.350 5.594	6.171 5.373	5.927 5.071	2.761 1.164	

TABLE 3
UNIT COST CHANGES FOR IVHS

Cost Component	Unit Cost	<u>Rationale</u>						
Market-Priced Costs:								
<u>Vehicle</u>								
Operation	8.4 cents/VMT	cent added for veh. gadgetry						
Ownership	\$ 3.22/trip	10 cents added to veh. cost						
Highway								
Oper. & Maint auto	2.3 cents/VMT	0.5 cent added for oper						
bus	3.4 cents/VMT	0.5 cent added for oper						
Added capacity auto	56 cents/added VMT	6 cents reduced for efficiency						
bus	90 cents/added VMT	9 cents reduced for efficiency						
Safety & Security								
Accident (market) auto	3.2 cents/VMT	cent reduced for acc. savings						
bus	6.4 cents/VMT	1 cent reduced for acc. savings						
rail	1.68 cents/VMT	No change						

FIGURE 1

FULL COST ACCOUNTING Travel Inputs



NEAR-TERM RFID APPLICATIONS IN TRANSPORTATION SYSTEMS

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INTRODUCTION

Current or near-term applications of radio frequency identification (RFID) technology demonstrate positive environmental contributions in the IVHS arena. Today, the use of RFID technology in intelligent transportation systems are most obvious in Electronic Toll and Traffic Management (ETTM), Commercial Vehicle Operations (CVO), and Automatic Equipment Identification (AEI) applications. The primary environmental benefits of RFID-based ETTM and CVO applications are gained from relieving congestion and improving the efficient and safe movement of vehicles. RFID-based AEI applications also favorably impact the environment, chiefly through operating efficiencies gained from improved asset utilization. Following are explicit examples of some of the ways in which RFID technology in transportation systems promote environmental benefits.

ELECTRONIC TOLL AND TRAFFIC MANAGEMENT (ETTM)

ETTM applications provide integrated revenue collection and traffic management information systems. These applications address key environmental considerations through:

- Optimizing the use of existing transportation infrastructures to minimize environmental encroachment.
- Improving traffic and operating efficiency, minimizing wasted energy and toxic emissions.
- Implementing congestion pricing to discourage excessive usage and encourage use of mass transit options.
- Improving the safety of passenger travel, circumventing any environmental hazards resulting from accidents and congestion.

Establishing ETC in a toll lane requires minimal additional hardware -- a reader system, RF module (which generates the RF signal) and antenna. Vehicles are equipped with tags, or transponders, that are "read" as they pass through the RF field in the lane. These systems contribute minimal electromagnetic emissions to the environment and always comply with governmental safety regulations regarding human radiation exposure. Systems that use "reflective" tags do not even generate a signal of their own, but simply bounce radio signals back to the broadcasting antenna. Thus, RF emissions are confined to a small area around the antenna.

Infrastructure Optimization

Environmental encroachment can be minimized through the optimization of existing transportation infrastructures. Toll authorities have found that lanes equipped with RFID-based electronic toll collection (ETC) systems can process vehicles far more efficiently than cash collection lanes. It takes only a fraction of a second to process an electronic transaction; throwing coins in a basket takes several full seconds and manual collection can take substantially longer. The ability of ETC lanes to substantially increase the capacity of existing lanes defers the necessity to invest in the more expensive and intrusive means of expanding capacity -- expanding the right of way with concrete and steel.

RFID allows tag equipped vehicles to automatically conduct toll transactions while moving past a reader. This allows drivers to pay tolls without stopping, therefore increasing throughput capability in the lane, which allows for increased capacity. This fully supports IVHS goals to enhance the capacity and efficiency of highways.

Traffic and Operating Efficiency

Several examples exist in which RFID technology is used to relieve congestion and facilitate the flow of traffic. Congestion is one of the key problems at toll barriers, and improvement in throughput benefits the environment through reduced emissions and reduced vehicle wear and tear. An analysis completed by Berger, Lehman Associates, P.C., at the Tappan Zee Bridge in New York, indicated that the increased capacity resulting from improved throughput with ETC would improve air quality in the vicinity of the toll plaza, decrease noise levels during morning peak periods, and result in a net decrease in electrical energy use at the toll plaza.'

Automatic vehicle identification (AVI) tags installed on vehicles can also serve as intelligent "probes" which relay information regarding highway traffic flow and travel times to a traffic management facility. The Texas Transportation Institute recently implemented such a program under contract to the Department of Transportation in the Houston area. Using data primary from existing ETC tags, information regarding travel times and alternate routing advisories is provided to motorists via variable message signs on the roadway or through local radio broadcasts. Traffic advisories encourage the use of alternate routes on high occupancy vehicle (HOV) lanes and toll facilities.' Probe data can also be analyzed in real time for incident detection. The use of common AVI technology for all ETTM functions reduces the overall hardware required to implement cost effective solutions in high congestion regions.

Excessive Usage and Mass Transit Options

The implementation of road access pricing with ETTM systems can likewise help to manage congestion. Although this method of traffic management has not yet taken hold on a large scale in the United States, it has been shown to be a cost-effective method to reduce congestion. The Los Angeles International Airport (LAX) is a recent example of the success of road access pricing. To meet the increasing demands for curbside space, airports tried a variety of solutions and found access fees to be most effective. The LAX access fee collection system, originally based on an honor system, was enhanced through use of RFID-based automatic monitoring. This solution not only further reduced traffic congestion by 20%, but increased revenues collected by more than 250%, allowing for a reduction in the fee schedule.3

With ETTM systems in place, travelers can be encouraged to consider more energy-efficient modes of mass transit or car pooling, leading to a decrease in the number of single occupancy vehicles on the road. For example, ETC lanes at the Lincoln Tunnel in New York and the Cross Harbour Tunnel in Hong Kong are dedicated to bus-only traffic, thus speeding HOVs through the toll plaza. Other identified uses for the technology include priority traffic-signal timing for HOV lanes, managing shuttles for special events, and provision of bus or people-mover terminal information. Virtually all vehicle based transit systems can be better managed using AVI technology, thus making mass transit options even more attractive.

Improving Safety

ETTM systems not only help drivers avoid delays and reduce congestion, but also improve safety. Accidents are more likely to occur at or near toll collection plazas and barriers as drivers slow their vehicles, fumble for change, and change lanes to position themselves to pay tolls. ETC lanes that do not restrict the normal flow of traffic are safer for motorists. In its first year of operation, the Oklahoma Turnpike Authority reported noaccidents in any of its ETC lanes, while multiple accidents occurred on conventional lanes.

Electronic traffic management systems can also improve safety by warning motorists of approaching road hazards so drivers can avoid the area, just as they make informed choices based on congestion traffic advisories. On-board devices that provide this type of information are destined to be part of future vehicle-roadside communication systems.

COMMERCIAL VEHICLE OPERATIONS (CVO)

CVO applications provide fleet managers economic incentive to maximize environmental benefits through:

- Environmental benefits directly resulting from improved economies of operation,
- Improved safety of freight movement, preventing vehicle failure and operator errors resulting in accidents, spills, fumes, etc.
- Non-stop implementation of state **line** and port-of-entry monitoring to eliminate unnecessary stops and starts for interstate trucking.
- Real-time vehicle status and information exchange to monitor environmental controls, alarms and hazards.

Real Time Status and Information Exchange

RFID tags used in commercial vehicle operations provide valuable vehicle status and information exchange. "Dynamic" tags that interface with on-board sensors and other monitoring devices can store valuable sensor data which can then be read remotely by roadside readers. Dynamic tags are particularly useful in tracking and monitoring vehicle and cargo status while en route. Specific examples include reporting fuel levels, temperature deviations, shock impacts, tank pressures, leaks, and system failures. Other examples of RFID applications used by fleet managers today include automatic fuel dispensing and shut-off, and automated scale systems to ensure safe loading.

Non-Stop Interstate Trucking

Motor carriers using AVI for non-stop state line and port-of-entry monitoring improves the movement of shipments by allowing trucks to bypass inspection stations. Not only can truckers make better time without stopping at toll booths and weigh stations, but they also reduce engine wearfrom repeated stopping and starting, save wasted energy, and decrease toxic emissions. Such a system has been in operation on the New Mexico border for over four years, benefitting over 8,000 drivers who regularly travel along the I-40 corridor.

AUTOMATIC EQUIPMENT IDENTIFICATION (AEI)

RFID-based AEI applications allow rail, motor freight, maritime, ports/terminals, and intermodal transport companies to effectively move and track shipments, improving asset utilization and processing time, minimizing fuel consumption, infrastructure, and equipment needs.

The use of a common RFID tag across all transportation modes is slowly becoming a reality. National and worldwide standards adopted by multimodal transportation bodies assures compatibility among systems and across jurisdictional lines. Collectively, these standards allow companies to globally track cargo through various transportation modes and regulatory environments through use of "frequency agile" tags capable of reliable operation no matter which frequency band is used in various locations.

Users benefit from the adoption of these standards -- extensive independent testing during evaluations of alternate technologies provide substantiated evidence of equipment performance. Reliability and accuracy, for example, is of utmost importance in monitoring the transport of certain shipments, particularly perishable goods and hazardous materials. RFID products that conform to the ISO 10374 standard for containers require a reliability level of 99.99% (not more than one non-read event every thousand readings) and an accuracy level of 99.9999% (not more than one undetected wrong reading in one million readings).4 These stringent performance requirements ensure that RFID systems will adequately perform even while exposed to the harsh environmental conditions of marine, rail and road transportation (sand, dust, salt, grime, heat, cold, etc.).

Near-term AEI applications will monitor tanks and equipment, track hazardous waste shipments, and effectively provide environmental safeguard measures. AEI tags can contain precise information regarding the content of shipping containers, as well as monitor the status of their contents. Trucks or train cars carrying hazardous materials can be monitored and checked automatically for compliance with local and other governmental regulations. These same systems can help ensure that shipments remain intact and undamaged during transport.

SUMMARY

Although its use is gaining in momentum, RFID technology is just beginning to affect the nation's transportation system in several key areas. Current or near-term applications of RFID technology in Electronic Toll and Traffic Management. Commercial Vehicle Operations, and Automatic Equipment Identification are favorably impacting the environmental aspects of providing more efficient, productive and safe transportation systems. Use of compatible systems across multimodal transportation systems facilitates increased utilization of these systems, further leveraging their positive effect on the global environment.

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INTELLIGENT TRANSIT INFORMATION SYSTEMS

Sally J. Spadero Landnet

To date, Intelligent Vehicle Programs have largely benefited single occupancy vehicles (SOVs) with the primary focus being technological solutions to improve the efficiency of road networks. From an environmental perspective, however, the most intelligent vehicle is one that you do not drive. For IVHS to be truly successful, attention should be shifted toward alternatives to SOVs. In an era where the top 10 automobile brands spend \$1.99 billion a year to promote their vehicles,' IVHS programs need to place emphasis on projects which market transit systems and improve access to information about transit systems and options. Broadcast quality multi-media production, dedicated cable television channels and geographic information systems are powerful tools to make transit information more accessible. It is our contention that access to high quality information about transportation options would result in significant increases in transit ridership and shared rides.

This paper will introduce three concepts which bundle intelligent technologies for the purpose of improving transit by improving transit information systems.

- "GO-TV" is a regional Cable TV, multi-modal transportation channel created to bring accurate, online information on traffic systems and conditions into the home.
- "MYRIDE" is a GIS based system to produce personalized routes and schedules for commuters, ideal for batch processing by large employers.
- "INFOSHELTER" presents accurate route and scheduling transit information at bus shelters.

These three concepts market directly to preference riders. Many people take transit because they must. Providing for the transportation needs of those who cannot afford, or are incapable of operating, a car represents an important social justice function of mass transit. Yet, if significant gains are to be made in environmental quality and "community livability," mass transit must also reach out to those who do not need to use transit. Transit operators, to fulfill this goal, must cultivate a strong positive image. They must improve communication of multimodal scheduling information in an attractive and interesting format. Finally, transit must create for itself a positive physical presence in neighborhoods. Intelligent transit programs should, therefore, focus on the marketing end of operations, for it is here where significant ridership gains are to be made.

GO-TV

Traffic reports have become a mainstay of daytime radio and are creeping into the information mix available on morning and afternoon TV news programs. We have come to rely on these reports, like weather reports, to help us prepare for our day. Trouble is, traffic information alone allows only for route choices and does not promote shifts in mode choices. Studies have demonstrated that commuters will consider changing their transportation mode based on pre-trip information.' Commuters and travellers contemplating alternatives to the SOV must have easy access to reliable information in their homes, before they get into their cars. "GO-TV" is a concept to create a regional Cable TV, multi-modal transportation channel to fill that need. The effectiveness of broadcast video communication surpasses audio or graphic presentation and will make quantitative transportation information both appealing and meaningful. By presenting this information with broadcast quality production techniques, a multimodal transportation channel will attract a viewership large enough to significantly impact ridership.

A proposal to demonstrate "GO-TV" in the Metropolitan Boston Area is pending before the Transportation Research Board. A pilot program will be produced and tested in focus groups composed of commuters and travellers to determine program format appeal and demand for specific information. We believe that "GO-TV" will be a

success as commuters realize the extent of traffic problems caused by the construction of Boston's Central Artery Project. Placed in context along side images of massive traffic tie ups, alternatives to SOV's will be looked at in a new light; as realistic, often preferable, options to the personal automobile.

"GO-TV" will disseminate information on both system conditions and transportation options. Commuters will see live video signals of road conditions and hear on-line traffic reports to allow them to make appropriate route choices. Commuter travel segments will present route, schedule and pricing information for all available transportation modes including: bus, van pool, commuter train and subway to afford commuters the opportunity to make mode choices. Regional travel segments produced will present schedules for: AMTRAK, airlines and intercity bus lines. Moreover, the channel will keep travelers aware of how changing weather conditions impact Metropolitan Boston's transportation network.

Intelligent use of a regional cable network will allow this channel to become an unparalleled source of regional and local transportation information. Because each cable franchise is community based, a regional cable network allows for programming information to be community "addressable", customizing a portion of the programming cycle for transit schedules and transportation options for that particular community. Community specific, broadcast quality on-line transit information in the home is critical if people are to broaden their awareness of their transportation options and become less dependent on automobiles.

MYRIDE

The current difficulty in obtaining specific route and schedule information presents another significant impediment to transit usage. MYRIDE is a concept to print personalized schedule and route information on demand from a home or office. MYRIDE would provide potential transit users with the transit information they need to use the system.

A Geographic Information Systems (GIS) will serve as the primary intelligent technology for MYRIDE. Street and address information can be linked using a GIS to transit routes and schedules. This information, in turn, can be used to create customized information schedules for potential transit users. A system can generate a route map with recommended stop, time elapsed and walking distance to stops and any appropriate route or mode transfer information. This transit "ad-matching" tool is most easily applied through batch processing of personnel lists from large employers. A municipality could use it to match new residents' home and work commutes. Processing can also facilitate the arrangement of car and van pools. The matching can also be made available to inquiry via: modems, touch tone phones, and fax machines to allow for individual inquiries, non-work trips and small businesses.

MYRIDE will perform two useful functions. As an employer based system, it will allow transit to market directly to persons who may have never considered transit or shared rides as an option. As an on demand system, it is vastly superior to collecting hard copy schedules from limited distribution points or accessing phone systems which cannot supply maps or personalized schedules.

INFOSHELTER

Transit stops represent critical marketing and information distribution nodes. Here, as potential preference riders wait, their opinions of the service are formed and reinforced. Transit stops must be intelligently designed to retain these riders. There must be sufficient information within the shelter to let the rider know that this stop is on the desired route. Three levels of information display can be considered.

Sign INFOSHELTER. Route, stop and transit operator identification are elemental to all locations. Permanent maps would convey route and, separately, complete system information. Printed schedules for routes should be posted. A shelter name, which would correspond to the printed schedules, would help riders and reinforce neighborhood identity.

- Bus Tracking INFOSHELTER. Intelligent technology applied to this basic bus stop could tell the rider where the bus is. By placing transmitters on buses and receivers on the shelters, a bus can be tracked as it moves along its route. Information can be displayed using lights on a durable map or on a video monitor. This dynamic map will relieve the stress, very real to those accustomed to using cars, of wondering whether the bus will ever arrive. From an operational perspective bus tracking can also be used in a central dispatch area to monitor and improve system performance.
- Interactive INFOSHELTER. In its most advanced form bus shelters can be equipped with MYRIDE capabilities. A rider could query the system map and GIS through a computer touch screen or voice recognition system. Route information could be delivered via printed map, as described above, or on a video monitor.

While the decision as to the level of sophistication for information within the shelter will ultimately depend on budget and ridership, in all cases stops should be designed to prevent riders from feeling lost.

CONCLUSION

If a bus runs on a scheduled route and potential riders are unaware, is it service? Yet, much transit service, particularly bus, van and carp001 service operates in this manner - quietly underutilized. Two significant impediments to increased transit usage are a general lack of marketing information about the full range of transit options available and poor access to scheduling and route information. IVHS programs such as we have outlined specifically address these programs.

LandNet believes in cost effectively improving the efficiency of our transportation system. Improved intelligence is not merely a matter of the application of advanced technology. We must be just as concerned about whether a proposal is good policy as whether it is smart engineering. We also must ensure that our purported intelligence does not come at the expense of common sense. I believe the specific transit projects put forth here meet this definition of intelligence.

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HIGH TECHNOLOGY TRANSPORTATION AND THE INFORMATION HIGHWAY A GLOBAL MARKET STRATEGT FOR THE UNITED STATES

Ellen Williams

TRANSPORTATION INVESTMENTS AND THE GLOBAL MARKET

The United States has a significant opportunity in the global market place to establish dominance in high technology transportation. A major confluence of economic, societal, and technological trends and an infusion of public funds for transportation has created this opportunity.

Gaining maximum advantage from transportation investments will require innovative and creative thinking as to how those fund should be spent. With precious few capital dollars available to invest in the United States, we must spend available dollars in a way which yields maximum return on the investment. We cannot afford to spend those dollars without some kind of vision of how those dollars fit into an international economy. According to Dr. Michael Porter, in his book *Competitive Advantage of Nations*, "choosing a domestic focus in a global industry is perilous, no matter what the firm's home nation."

THE HIGH TECHNOLOGY TRANSPORTATION STRATEGY

If we choose to spend transportation dollars in ways which create a competitive advantage, then how do we spend those dollars? That is just the question asked by a group of California leaders participating in what is known as Project California, sponsored by the California Council on Science and Technology. The group's focus is on six major transportation industries: high speed rail, alternative fuels, Intelligent Vehicle-Highway Systems, electric vehicles, mass transit, and advanced telecommunications. From these industries, they want to know what is the best way to build a sustained economy which creates jobs especially for the defense industry worker. "The state is serving", observed Malcom Currie, retired chairman of Hughes Aircraft Co., "as the prime research laboratory for the rest of the United States, Japan and Europe. . . . We need to turn our research into products and jobs. . . "

In terms of creating a sustained economy and jobs, Project California's assessment of high technology transportation is now available. The assessment places Intelligent Vehicle-Highway Systems and Advanced Communications and electric vehicles at the top of the list. Those three areas have the best chances of producing jobs and a highly sustained economy. Although I could build a strongcase for all forms of high technology transportation to create a globally competitive industry, for the purposes of this essay, I intend to focus on the investment in a ubiquitous high capacity Advanced Communications System or "Information Highway" for the purpose of moving images and information. After defining the "Information Highway," I will discuss how it competes with Japan and major countries in the European Common Market and how it provides ancillary benefits to the United States.

INFORMATION HIGHWAY DEFINED

An Information Highway, from a technology perspective, is everything it takes to deliver images and information from point A to point B. This includes communications networks, personal computers, information appliances, televisions, cable networks, systems applications, information storage devices, facsimile, multimedia. it means using this highway to deliver health care services to the patient; education to the student from the worlds teachers; information to the researcher from the world's libraries, governmental services to citizens and energy management information to residences.

The Clinton/Gore administration also thinks part of the investment in infrastructure needs to go beyond traditional transportation to include a high speed communications infrastructure. The goal is "... a nation that uses

information more effectively than industrial rivals--is no less ambitious than the construction of the transcontinental railroad system or the race to put a man on the moon."

Current efforts to build the Information Highway are extremely fragmented, resulting in many failed attempts to deliver an Information Highway Platform available to everyone. For example, education leaders try to build separate networks to support education. Financial institutions try to build their own consumer networks. Library leaders want to build separate networks for electronic libraries. Consumers have to buy their own personal computers and facsimile machines to receive information services. And even information policy leaders try to lead from the point of view of the advantages associated with high tech. We need a new approach. Perhaps we can learn from those who built the Interstate Highway System where combinations of public and private dollars produced, for its time, the most enviable surface transportation system in the world. That principle can be applied to the construction of a high speed public access Information Highway designed for the purpose of moving images and information wherever possible.

To make the Information Highway happen, what is needed is a coordinated, systems approach to maximizing the benefit of technologies and network platforms in the global market place. It is an issue of leadership and public policy. We have to make decisions to place value on transporting, wherever possible, information and images, as the most cost effective, energy efficient, non-polluting, fastest way to travel.

According to Albert Gore, "Our current information policy resembles the worst aspects of our old agricultural policy, which left grain rotting in thousands of silos while people were starving. We have warehouses of unused information 'rotting,' . ." ⁴ It is information which is the capital of the Information Age just as iron ore was to the Industrial Age. We can not afford to leave information rotting in silos. Information delivered in an easily accessible, rapid format can make the difference in our industrial competitiveness. "The critical difference between now and twenty years ago is that the manufacturer can no longer just use more energy to increase productivity. It's too expensive. Instead, the manufacturer has to become smarter at what he(she) does."5 Therefore, if we want to manufacture a new product or service, having access to the "information silos" is critical to being able to produce that product in the most cost effective manner.

DIFFERENT INFRASTRUCTURES FOR DIFFERENT TIMES

Different infrastructures are needed for different times. In an agricultural economy, emphasis was placed on cheap methods of moving bulk grains i.e., an orientation toward canals and rural roads. In an *industrial economy* more emphasis was placed on rail, ports and trucks for goods movement. However, in an *information economy*, as we are in today, the greatest emphasis has to be placed on the movement of information. In fact, Alvin Toffler, noted futurist was heard to say, "If we are in the midst of an *information economy*, then why to we spend billions to fix pot holes?"6

GLOBAL CONTEXT OF THE INFORMATION HIGHWAY

No other country in the world has placed focus on the value of using communications and information technologies to move images and information for transportation purposes. If the United States were to lead an effort to build Information Highways, three things would happen. One, investments in information highways creates exportable products in software, hardware and systems platforms. Two, investments in building ubiquitous high capacity information highways provides a cost effective solution to other infrastructure problems associated with education, health care, library services, and public services. Three, the information highway would provide a transportation alternative which is not highly dependent upon energy, thereby reducing the United States from the vulnerability of fluctuating oil prices.

Creation of the Information Highway means the creation of a whole new epoch of products and services that can be delivered over a public access high capacity network. Seventy percent of the high capacity networks are privately owned. Just think of how travel behavior might change if this capability was publicly available to everyone in their homes. The same network used for meetings can be used for a full compliment of services including the

delivery of health care, education, governmental services, financial services and more.

Public policy leaders have often expressed concern regarding the creation of an information-rich and information-poor society based on a person's ability to use a computer. Most of this concern is because, with our current infrastructure. to gain the benefits of an information society means being computer literate. However, this becomes a non-issue in an environment of broad band technologies to homes. Instead of using a computer to gain information, information is delivered in the most commonly used delivery format -- television, and television in a two-way, interactive format.

ANCILLARY BENEFITS

Once the platform is in place for the delivery of information in video format, new users and information providers would begin to evolve. Health care, for example, changes when it becomes possible for disease prevention information to be universally delivered to everyone in the privacy of their homes. In the case of public health, advocates for high capacity Information Highways into homes state, ". .the first task in developing a responsible General Public/Health Information Interface is to get health information and decision-making tools to people before they enter the health system all too often presenting an urgent, high-cost problem which sometimes can no longer be resolved."7 This leads to the next point, investments in the Information Highway bring other infrastructure improvements. In the global economy, in order to be competitive, we must address other major infrastructure issues including education and health care. With the Information Highway in place, new paradigms for the delivery of these services can take place. Be it the classroom or the home, the world's leading educators would become available to everyone. Vocational education programs could be delivered from anywhere to everywhere. Health care changes into preventive health care with patient/consumers making informed choices of how they want to live.

BECOMING LESS CONSUMPTIVE

Energy savings and independence is another ancillary benefit of the Information Highway. Spending money on more costly forms of energy to provide goods and services robs us of the capital dollars needed for investments in our economy. We spend more money on energy largely due to the way we organize. We are paying the price for the choice we make to have the house on a plot of land, unlike the rest of the world that is much more concentrated around transportation facilities and uses high density housing principles. Energy savings resultingfrom the delivery of services in an information format, instead of more expensive forms of transportation, quickly becomes energy redeployed toward making goods and services less expensive and more competitive in the global market. We become less consumptive with the Information Highway. Notable economist, Dr. Robert Meyers, Principle Economist, World Bank points out, "We have to become a less consumptive society in order to be globally competitive."*

INFORMATION HIGHWAYS IN JAPAN AND THE ECM

Our global competitors Japan and the European Common Market are not without a plan for making an investment in advanced communications systems. We are at the point where we must make the investment in the Information Highway or fall further behind. "But there is a risk of doing nothing, too. The Japanese government has committed to investing about \$120 billion by 1995 to develop a new communications infrastructure. Although a similar U.S. effort could exceed \$200 billion, computer makers believe investing in new digital communications technologies will pay off by creating thousands of jobs."

In France, a low technology Information Highway already exists. It is known as the Minitel. Although the French do not view the Minitel as a part of their transportation system, it is, in fact, part of their system. Seven years ago the French made the decision to provide its citizens with an information appliance which would be used for access to what would be the equivalent of White Page and Yellow Page information. By doing this, they no longer would use a paper-based information service. Because the French created a ubiquitous information platform, they now have 18,000 information providers using the system which after six years of operation makes Minitel a totally self-funded information platform. Upon closer examination of the Minitel, information services actually expand France's transportation system delivering or example, financial, library, education, and health care services.

Even with Japan's investment in advanced communications and France's Minitel, the United States is in the best position to set the defacto standard for a high capacity, public access Information Highway/Advanced Communications Platform. Public access will make the difference in the economic value of investments in advanced communications.

The reason why Japan and Europe may not have the same scale of benefit as the United States has a lot to do with cultural orientation. Both Japan and the European Common Market countries are still very oriented toward industrial organizing principles. To gain the real benefit from Advanced Communications means a willingness to use decentralized organizing principles. Despite concerted efforts on the part of the Japanese government to encourage decentralization, the Japanese continue to be highly concentrated in a few urban centers. The Japanese business culture is based on face-to-face interaction and they are willing to incur great costs to perpetuate the culture. The cost has come in terms of long commutes, expensive housing and poor quality of life. Until their culture changes, the real benefit of a public access Information Highway cannot be available to them. Their investment in advanced communications will likely be oriented toward closed organization systems. In Europe, there is a much broader issue of cultural and language diversity. Also, they use the industrial, centralized organizing principle. The presence of a European Common Market does not necessarily assure full participation in a common ECM Information Highway platform. Nationalism is alive and well.

For the United States, we are already beginning to use the decentralized organizing principle, particularly for work-related activities. According to Link Resources, over 40 million people are already working full andpart-time from their homes. Corporations are decentralizing through satellite facilities located in rural areas.

"Pressured by rising global competition, U.S. companies operating in big cities were faced with some hard questions: Can we afford to pay \$50.00 a square foot for office rent and \$11 an hour to people who clean our floors? Can we continue to attract top-notch employees if up to 40 percent of their adjusted gross incomes will be devoted to housing? Can we compete in the world economy with workers who have graduated from substandard high schools where drop out rates often exceed 35 percent? For more and more businesses the answer is, "No." "10

Even though corporations have begun to decentralize through communications and information technologies, the full benefit of being able to decentralize is not available because there is no provision for ubiquitous access to a high speed Information Highway which would make the same services that are available to a corporation available to home consumers.

In education and health care, we have early examples of using technology to distribute services. Education has long been the front runner of using video technology for distributed education. The next leap is to have a video repository of lectures where a student could call up a given lecture on demand. Increasing the bandwidth into homes will make this possible. Health care already has example of patient care through remote patient diagnostic systems which monitor patient health care over the current communications network. Many more examples exist, but the point is the willingness of Americans to be innovators and to try doing things a different way. In doing this, the United States stands to have the best chance of realizing the full potential of a common, public access Information Highway.

CONCLUSION / RECOMMENDATION

To become the international leader in the provision and use of Information Highway technologies products and services is a leadership issue -- not a technology or even a cost issue. It is where will we place our public policy emphasis as we go into the 21st Century. "Telecommunications infrastructure should be the heart of public policy at the state and federal level. Building a telecommunications-based infrastructure is a national economic need, not just a social need.""

We need all forms of transportation to produce the world's highest levels of mobility, whether it is moving people, goods, services, or information. The infusion of information and communications technologies in all forms

of transportation will serve to differentiate the United States transportation system while producing a global industry.

Success in leveraging high technology transportation in the global market place must include a public/private economic development effort. The United States must be viewed as the place to come to see the "Information Transportation System" and the world model for this system. We cannot afford to lose this emerging industry. When people come to view the United States transportation system, they will see Intelligent Vehicle Systems making it possible to increase the utilization of our current surface transportation system; our electric vehicle industry; smart rail cars in the rail system; high speed rail; cars using alternate fuels; a fully integrated public transit system which tells the traveler, before they depart, when and what is the best route to travel; and the most technologically advanced Information Transportation system in the world.

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II Energy and Environmental Issues

INTELLIGENT VEHICLE-HIGHWAY SYSTEMS AND BICYCLING

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ABSTRACT

Intelligent Vehicle Highway Systems (IVHS) have important implications for bicycling. Such systems may be designed to specifically encourage and facilitate bicycle transportation, although technology of this nature offers little to directly address the well documented impediments to bicycle transportation. More importantly, IVHS will likely effect the bicycling environment as a side effect of its main design function.

This paper examines direct IVHS applications for bicycling other applications that will effect bicycling, and assesses the impacts of major proposed IVHS projects on the bicycling environment.

BACKGROUND

Many proponents and opponents of IVHS technologies acknowledge that IVHS is only a tool that can be used to increase vehicular occupancies or to "fit" more vehicles on a given roadway. Many proponents see growth in vehicle miles travelled (VMT) as inevitable, and IVHS as the most efficient and effective means to accommodate this. Proponents argue that there are many positive IVHS applications, including efficient road pricing, measures to accommodate ride sharing, and prioritization schemes to speed transit service, which improve air quality, increase vehicular occupancies, and provide mobility to the transportation disadvantaged. Many opponents acknowledge this potential but are concerned that putting this technology into the hands of state highway departments will inevitably lead to system capacity improvements which will have the opposite effects. Opponents believe that investing so heavily in IVHS demonstrates a high perceived value in its uses, before such uses have even been decided.

Many in the bicycling community share this belief. At the federal level, USDOT has demonstrated only marginal interest in bicycling. As an example, USDOT took well over a year to fill the vacancy of the only bicycling and walking position (out of about 1,000 jobs) in the Office of the Secretary (OST), and filled it only after a Congressional mandate, relentless pressure from the bicycling community, and the potential embarrassment of having the release of the Congressionally mandated National Bicycling and Walking Study being marred by this vacancy. While budget constraints precluded spending about \$50,000 to put a full time program manager in OST, they did not get in the way of increasing the USDOT research budget from \$647 million in 1993 to \$688 million in 1994, 80 percent of which will be spent on IVHS. This is a huge budget for a program with an ill-defined mission. Bicycle activists and others who have traditionally been left out of the transportation decision-making process are understandingly reluctant to trust powerful highway departments to ensure that their interests will be incorporated into the application of these technologies. When the U.S. Secretary of Transportation addressed the Transportation Research Board and Congress at the beginning 1994, he touted the virtues of IVHS technologies in solving our transportation problems but said nothing about land use, traffic calming, or bicycling accommodations. Bicycle activists are reluctant to support the technology solution, when its main proponents do not define the national transportation problems as they do.

Bicycle and neighborhood activists share a perspective on the use of street space that differs from that of the highway engineer. The former are concerned with maintaining the quality of destinations, not merely enhancing travel efficiency. They are concerned with how streets function in terms of allowing or obstructing social interaction and their effects on the human environment. Bicyclists, more than motorists, are concerned with the travel experience. An important aspect of bicycle transportation is that it can be combined with exercise and recreation, essentially allowing multiple functions to be served with a single trip. Excessive automobile traffic combined with an automobile-oriented design (large signs, billboards, parking lots, etc.) makes the roadway environment unpleasant.

While many motorists may tolerate this because they believe they have no choice, many bicyclists will opt to become motorists for utility trips where route choice is limitted, thereby bicycling only for recreation. IVHS seems to concentrate on quantity and efficiency--getting the maximum movement of people and goods using a minimum of road space--but it seems to ignore the importance of neighborhoods and the environment in discouraging trip-making and encouraging the use of alternative transportation.

BICYCLE-SPECIFIC IVHS TECHNOLOGIES

A number of bicycle-specific IVHS applications have been proposed. The most developed application to date is an intelligent bicycle routing program which allows bicyclists to enter origin, destination, topography preference, cycling ability, importance of route directness, and comfort on busy roads. The computer prints out a detailed route map with accompanying written directions accounting for these preferences. (See "Intelligent Bicycle Routing in the United States, Transportation Research Board Paper 930472, 1993.) While this IVHS application could certainly be useful to bicyclists, its utility is greatest where cyclists are unfamiliar with an area, and it is no more useful than a map in areas where cyclists are familiar with their general layout.

The European Cycling Federation (ECF) in "What Do Bicycles Have to do With Advanced Transport Telematics?" (August 1992) suggested applications such as providing weather forecast information, map information (including topography), and public transportation information (including bicycle transport information). One particularly innovative suggestion was a bicycle theft prevention system where computer chips which could respond to certain signals would be built into bicycles to identify the location of stolen bicycles. ECF also suggested systems that count bicycles on roadways to measure usage. Finally, ECF endorsed car warning systems which would warn turning motorists of bicyclists' presence.

OTHER IVHS TECHNOLOGIES THAT WILL EFFECT BICYCLING

At the most basic level, if the effect of IVHS applications is to reduce the number of vehicles on the road, then IVHS will benefit bicycling. The inverse is also true. Additionally, increases in motor vehicle speeds require more roadway space to allow "sharing the road," and thus are often detrimental to bicycling. The USDOT recognizes as a matter of policy that increased motor vehicle traffic and higher motor vehicle speeds make bicycling less safe and desirable. (See "Selecting Roadway Design Treatments to Accommodate Bicycles," FHWA-RD-92-073, 1994.) This is particularly important on main arterials and secondary roads that are popular for bicycle commuting and other utilitarian bicycling.

Capacity enhancements are explicitly recognized as one goal of IVHS in the Intelligent Vehicle-Highway Systems Act of 199 1 (see Part B of the Intermodal Surface Transportation Efficiency Act, Title VI, Section 6052 (b)(1)). Capacity enhancing IVHS applications such as signalization improvements and other "smart" technologies may apply directly only to freeways where bicycles are either prohibited or their usage is very low. While adding motor vehicle traffic to these roadways may not concern bicyclists directly, the fact that these vehicles are used for trips that start and end on major arterials and secondary roadways is a major concern. Even measures to reduce travel demand, such as congestion pricing, may adversely impact bicycling if such pricing is applied only to freeways and motorists attempt to avoid them by using secondary roadways.

SPECIFIC APPLICATIONS

A large number of proposed IVHS applications would have little or no effect on bicycling. Given the tremendous financial resources that are being provided for these applications, many bicycle activists believe that the money could be better spent on bicycle lanes, traffic calming measures, bicycle parking, and bicycle/transit accommodations. Nonetheless, these "neutral" IVHS applications are not what most concerns bicycle activists.

USDOT and IVHS AMERICA issued their April 1994 Interim Status Report, *IVHS Architecture Development Program.* which identified 28 different user services. Many of these services, such as pre-trip travel information, traveler services information, incident management, commercial fleet administrative processes, and

emergency vehicle management, would have little or no effect on the bicycling environment. Some user services could worsen bicycling conditions by encouraging solo driving. Examples include some route guidance and traffic control applications. Some user services would benefit bicyclists by getting motorized vehicles off the road. Examples include many of the public transportation applications such as ride matching and reservation and personalized public transportation.

The Interim Status Report mentions only positive implications of IVHS and does not even acknowledge the possibility that some IVHS applications could have negative implications. In a few instances, the report states that bicyclists and pedestrians will benefit from specific IVHS applications. It says, for example, that hand held devices can be used to give bicyclists and pedestrians route information. But bicyclists and pedestrians would need to have these devices with them, and these devices would probably be quite costly and, except in limited cases, provide only minor benefits to their users.

The report also says that traffic control measures which would be used by vehicle drivers and public transportation operators would benefit bicyclists and pedestrians from improved traffic flow. This is a stretch and could actually have the opposite effect if motor vehicle speeds were increased as a result.

The effects of many other IVHS applications on bicyclists are not acknowledged by the report. One application is an electronic payment system using smart cards. Related to this idea, one author has suggested applying the cash-out concept to congestion pricing, that is, offering commuters free smart cards with cash values based on commute distances, which could be cashed out for a transit pass or money. (See "Applying the 'Cashing Out' Approach to Congestion Pricing" by Patrick DeCorla-Souza, Transportation Research Board Paper 940375, 1994.) While the cash-out concept would be good to create the political will to implement congestion and other road pricing schemes to discourage driving alone, offering higher valued cards to those commuting in from the outer suburbs would encourage locating in those suburbs. To encourage bicycling, people need incentives to live close to work, and cash out and other schemes need to be designed to provide such incentives.

The last broad category of IVHS applications is safety equipment. In general, such applications would benefit bicyclists. One such beneficial application is a warning system to alert motorists to the presence of bicyclists and pedestrians. Other applications, such as automated roadside safety inspections and on-board safety monitoring for commercial vehicles, would enhance overall roadway safety, as would many collision avoidance applications. But safety equipment such as automatic crash protection mechanisms may encourage drivers to be less careful, to the peril of other road users. There have also been a number of recent newspaper articles about cars with anti-lock brakes getting into as many collisions as those without them, to the dismay of insurance companies that provide discounts for this equipment. There is probably a limit on the effectiveness of in-vehicie safety equipment, and related IVHS applications should not be seen as panaceas.

Despite the report alluding to beneficial bicycling and pedestrian applications, the opinions of the bicycling community have not been solicited. League of American Bicyclists staff attended one IVHS AMERICA subcommittee meeting at the Transportation Research Board meeting in January 1994 and was informed that in order to attend subsequent meetings, a \$1000 membership fee would be required. Page 13 of the Interim Status Report explicitly refers to bicyclists as "non-vehicular travelers," which is not only untrue but is considered an insult by many bicyclists. Lack of understanding and inadequate communication have thus far precluded appropriate consideration of the interests of bicyclists in the IVHS program.

CONCLUSIONS

IVHS is coming whether or not the bicycling community likes it. Some of its applications are already here. Bicycling and other organizations will be keeping a close eye on how IVHS monies are being spent and will attempt to hold governmental entities accountable to the environmental, community, and bicycling and pedestrian transportation effects of IVHS expenditures.

The problem with the U.S. transportation system is not the lack of technology. Instead, it the lack of coordination with land use, and inadequate integration of land use, housing and transportation policy. IVHS may

help to address these issues, but it could also make things worse. With a tight budget climate, IVHS should be required to compete with other measures to prove its effectiveness and investment worth.

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THE GREENING OF IVHS' INTEGRATING THE GOALS OF AIR QUALITY, ENERGY CONSERVATION, MOBILITY AND ACCESS IN INTELLIGENT TRANSPORTATION POLICY

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IVHS is an amplifier. It amplifies both what is good and what is bad about our transportation system, and extends the consequences to other domains, such as energy, environment, and land use. In some configurations, IVHS technologies promise to boost mobility and safety dramatically, while at the same time inviting increases in vehicular pollution, demand for foreign oil, and inequality in transportation access. Travel safety and capacity enhancement are of course desirable, but what if their achievement comes at the expense of air quality, energy security, and perceived equity?

The answer to this question depends on fundamental assumptions about latent travel demand, modal choice, and the capabilities of vehicles and route guidance systems operating in the future, which in turn involve assumptions about technological innovation, commercialization, and government policy and enforcement with respect to emissions standards, fuel efficiency standards, transit use, and a variety of transportation control measures. Clearly, a doubling of capacity' on existing roadways would induce some additional demand, but would the increased number of vehicles emitting pollution and consuming gasoline be more than offset by the emissions savings and fuel savings gained from reduced congestion? And for how long? Would transit applications of IVHS compensate for potentially negative energy and environmental consequences of enhanced mobility for automobiles? And assuming that the paramount goal of IVHS advocates is the efficient movement of people, rather than vehicles, how are tradeoffs between access, mobility, air quality, and energy conservation to be decided?

No one should feel confident that these questions can be satisfactorily answered for all regions and circumstances in which IVHS technologies are envisioned. To a large extent, the answers depend on a combination of future behavior changes, market conditions, political leadership and entrepreneurial abilities that can only be dimly discerned today. Moreover, the lack of adequate, tightly coupled, system-wide models of modal choice, trip generation and distribution, on-road driving behavior, vehicle emissions, and pollution dispersion, suggests that no definitive answers will be forthcoming in the near future.

Rather than bemoan the lack of integrated, systemwide models, this paper seeks to refocus attention on the vehicle technology assumptions used by modelers. Recent advances in clean car technology -- e.g., electrically heated catalysts, remote sensing of on-road emissions, reformulated fuels, and ultra efficient, zero- and ultra low-emission "supercars" -- suggest that conventional projections of vehicle fleet characteristics with incremental improvements will overstate future environmental and energy risks of mobility enhancement. In other words, incremental extrapolation of today's vehicle inputs and outputs for purposes of IVHS simulation represents more of a political judgment than one based on technological foresight. The technologies needed for nonincremental change are becoming available with astonishing speed; it is the political will and administrative capacity to employ these green technologies that is, as usual, lagging behind. Even in California, where political mandates for clean car technology are strongest, public acceptance and scattered support from the private sector is wavering. Foremost among the reasons for concern is the huge gap that remains between policy goals and market incentives to develop zero- and ultra low-emission vehicles with ultra high fuel efficiencies.

Viewing IVHS as a potential amplifier of on-road vehicle emissions and fuel consumption implies that the critical factors in determining future impacts are the emissions control capabilities and fuel efficiency ratings of vehicles that are forecast to be on the road during each phase of IVHS implementation. While IVHS also can and should be used to amplify transit use and trip avoidance strategies, the assumption made in this paper is that the

impacts of such use, given transportation policies that satisfy near-term conditions of political and economic feasibility, will be small in comparison with the effects of cleaning up single occupancy vehicles (SOVs). For example, removing one vehicle from commuter traffic in 1992 using Southern California's rideshare program (Regulation XV) was estimated to cost nearly \$3,000.³ Investing the same amount of money in remote sensing and related programs for identifying and fixing, or retiring, gross polluting vehicles -- the roughly 10 percent of the vehicle fleet responsible for more than 50 percent of on-road emissions -- would result in emissions reductions that were, according to the author's calculation, at least 14 times greater, and probably much more than that. Similarly, air quality gains from light rail transit compare very unfavorably on an abatement cost basis with clean car programs, and offer little justification by themselves for the enormous subsidies involved in transit ridership -- up to \$8,000 per roundtrip passenger per year in Southern California.' While many proposed IVHS designs are biased to expand route choices for SOVs without first and foremost increasing modal choices (e.g., enhancing the *ease* of choosing existing transit systems), the strong likelihood remains that the negative energy and environmental consequences of this bias will shrink rapidly in the next decade as SOVs become much cleaner and, hopefully, more efficient.

Although transit enhancement, travel safety, and economic stimulation from technology development are all important objectives of IVHS, by far its greatest challenge over the next twenty years will be to double mobility for SOV trips, while enabling pricing strategies (e.g., congestion pricing) and "green" technology applications to achieve net reductions in vehicle emissions and fossil fuel consumption. IVHS by itself is unlikely to contribute greatly to the goals of environmental quality and energy security. It is primarily a bridge to other solutions in these areas, and its potential for *indirect* contributions is what matters most. Accordingly, IVHS should not be thought of as a bundle of end-state products linked to throughput efficiency so much as a set of *enabling* technologies for optimizing among the sometimes conflicting goals of efficiency, safety, equity, and sustainability. Given that there are tens- and perhaps hundreds-of-billions of dollars at stake, it is not surprising that the instrumental nature of IVHS has sometimes been lost in the scramble to transform IVHS deployment itself into a national goal. As the remainder of this paper attempts to demonstrate, however, the desirability of IVHS deployment depends heavily on how problems that are external to the transportation system are resolved.

CONSTRAINTS MAPPING

Because thinking about IVHS development and deployment continues to suffer from what Langdon Winner refers to as "reverse adaptation" of ends to means, there is a tendency within the IVHS community to regard issues of social equity and ecological sustainability as constraints rather than goals.' Some engineers, for example, may allow their fascination with IVHS as a technological means to shape their vision of social ends -- principally, mobility and safety, if not technological progress, itself. The investigation of technical requisites of IVHS deployment (e.g., systems architecture) has tended to far outpace investigations of its social, environmental, and institutional implications. As a result, much of the activity surrounding IVHS appears to foster "technology push" rather than "market pull" behavior, and efforts to gauge public acceptance have predictably emphasized consumer issues over those of community and neighborhood livability.

Despite the relatively lavish attention and funding devoted to matters of IVHS technical performance, systems integration, and cost studies, so-called "nontechnical" issues may ultimately play a more influential role in IVHS adoption than straightforward matters of market demand and technological readiness. Grassroots public acceptance and IVHS goal conformity with cross-cutting policies originating outside the transportation sector have already surfaced as pivotal issues in development and implementation. One way to appreciate the nontechnical barriers that stand in the way of rapid deployment of IVHS is to trace systematically the constraints that arise at each stage of implementation -- from conceptual design to full-scale operationalization. An abbreviated constraints map of this sort is presented in Figure (1). Following the conventional view that deployment is the goal. it treats all other variables as either bridges or barriers to that goal. Unlike a critical path diagram or a technology-centered risk assessment, the constraints map attempts to show how limitations in knowledge, finance, hardware, political support, and ecological carrying capacity can influence the strategies of public and private actors and institutions interested in IVHS, and how these strategies are linked to key enabling policies (i.e., ISTEA), which must later be reconciled with other policies (e.g., Clean Air Act Amendments, Energy Policy Act, Americans with Disabilities Act). and made compatible with co-evolving organizational structures and market forces.⁷

The fears and hopes that arise from technological innovation provide the basic driving forces for moving IVHS through the political constraints process that determines the fate of nearly all large-scale policies and projects, especially those that cannot claim national security status or the legitimacy conferred by crisis-driven decision making. These fears and hopes are themselves amplified and sometimes distorted through advocacy coalitions and media coverage. In the case of intelligent transportation systems, most of these fears and hopes are based less on assumptions about human travel behavior than on assumptions about the kind of vehicles and transportation alternatives that will be available in the near- to mid-term. Consider the effects of assumptions about modal choice and vehicle technology on some of the major arguments of IVHS critics and supporters listed below:

Fears of IVHS critics:

- Increases aggregate vehicle emissions and energy consumption due to increased trips and VMT
- Increases travel on arterials by diverted travelers, exposing many neighborhoods to greater smog, air toxics, and noise
- Perpetuates auto dependency -- a "reprieve" for SOVs (e.g., Increased auto dependence owing to induced land use patterns that increase average distances traveled by commuters as average travel times decline from congestion relief)
- Imposes large social opportunity costs (IVHS seen as a megaproject that uses up scarce resources needed for achieving other public goals)
- Exacerbates perceived inequalities among travelers (e.g., expense of onboard ATIS may widen gap between information-rich and information-poor travelers)
- Preoccupation with mobility will lead to further neglect of accessibility
- Fosters "dispersed" congestion (as opposed to congestion that is concentrated in CBD)

Hopes of IVHS supporters:

- Improves travel patterns to achieve congestion relief, and thereby reduces emissions and fuel consumption associated with congestion
- (*Related* to #I) Smoothes traffic flows, thereby reducing emissions and fuel consumption from repeated acceleration and deceleration
- Serves as a bridge to pricing solutions for use in demand management (e.g., road pricing)
- Enhances attraction of transit and paratransit programs through dissemination of real-time information, etc.
- Encourages ridesharing and trip linking among SOV operators by providing accurate traffic-sensitive and weather-sensitive travel information

THE CAR OF TOMORROW

The single most important factor for deciding whether the critics or supporters have the better case is the predisposition of the participants in the debate toward vehicle technology improvements. In the case of environmentalists, there are two major and competing predispositions: (1) that technology "fixes" have been greatly oversold and will cause more problems than they will solve, and (2) that technological solutions are promising, but unwanted because they undermine more basic environmental arguments for changing human lifestyles. To the first group, the concept of a "green" car is an oxymoron; to the second, it represents a paradoxical improvement and,

hence, a bonafide threat to the continuing campaign against the automobile as a symbol of environmental destruction. Having spent more than two decades trying to convince people to break their auto-dependency, the very real prospect of strong, safe, ultra-light, ultra-clean Supercars within ten year? can only be accepted by such groups with a certain amount of ambivalence.

Emissions Control

Since 1961, when California mandated the use of positive crankcase ventilation (PCV) on cars sold within the state beginning in 1963, emissions control for motor vehicles has developed into a major industry. The key advance came during the mid-to-late 1970s with the introduction of the catalytic converter, as well as engine gas recirculation and evaporative recovery systems. This was followed shortly by the improved three-way catalytic converter and by electronic fuel injection, which adjusts the air/fuel mixture to meet the exacting specifications of advanced emissions control systems. These advances made possible a 96 percent reduction in tailpipe emissions of CO and HC, and a 76% reduction in NOx, between 1960 and 1990. During this same period, fuel consumption per mile for new cars dropped nearly 50 percent and accidental deaths per mile declined 65 percent." In short, emissions abatement, fuel efficiency, and auto safety were all major technological success stories during this period, but their achievements were tempered by sheer growth in the number of vehicles, vehicle trips, and vehicle miles traveled. For example, total VMT increased by over 170 percent between 1960 and 1990. While most of this increase can be attributed to the addition of over 250 million new passenger cars registered during this period", per capita increases in travel and VMT also played a significant role. During the 1980- 1989 period, for example, VMT per vehicle increased 16 percent, contributing to an aggregate increase of 40 percent."

As progress has been achieved in emissions control and automotive engineering, more and more attention has been devoted to emissions caused by cold engines, vehicle acceleration and deceleration, and fuel evaporation. Emissions from what are called "cold starts" and "hot soaks" (emissions that occur at the beginning and at the end of a trip), account for roughly two-thirds of the total emissions from a ten-mile trip under normal driving conditions. If strong acceleration or deceleration occurs, large emission "puffs" will usually be produced as a consequence. Given that it is easier to improve emissions control technology than the driving behavior of tens-of-millions of Americans, potential solutions for cold start and hot soak problems look much more promising than public appeals to step lightly on the accelerator and brake pedals. While IVHS may make its most significant air quality contribution in this latter problem area by smoothing traffic, or providing automatic speed governors," the biggest payoffs are likely to come in the cold start category from the installation of new electrically heated catalyst (EHCs).

Because today's catalytic converters must reach temperatures of 250-300 C for optimal performance, the first few minutes of any trip undertaken with a cold engine is a period in which much of the exhaust gas flows through the converter without the catalytic action needed to breakdown harmful emissions. A cold engine typically requires over 100 seconds to heat the catalyst to its start-up temperature. While heated catalysts have been around for many years, the electricity they consumed from the battery made them impractical. Recent advances in EHCs, however, have brought the battery drain down from over 600 amps to about 175 amps (power and energy consumption level of 2 kW and 8 W-hrs. at 15 seconds duration). This is well within the limits of battery and alternator systems, and is sufficient to warm up some catalysts in as little as 5 seconds. Test results of the new EHC systems are summarized in Table 1 and suggest that a significant leap forward in emissions control technology is at hand. Total costs to vehicle manufacturers of producing EHCs (with light-off catalyst, but without precious metal) have been estimated to be \$95 per unit, assuming a production volume of 300,000 units. Total cost for a complete alternator-powered EHC system (loaded with precious metal, plus light-off catalyst, plus air injection components, switches, valves, and cables) is estimated to be \$165. During the startup phase, costs of these units will of course be higher, perhaps exceeding \$400 per vehicle.

Table 1

Emissions Levels of Different EHC Systems

(grams per mile)

Source¹⁶ Vehicle TypeCOHCNOx

Coming-0.620.020.16 SAE'88 Vo1vo0.460.060.07 ASME' 86 CamryO.380.030.25 ASME' 90 Celica0.400.030.05 ASME' 90 LeSabre0.250.020.18 CARB'90 LeSabre -0.030.27

Average (EHC-equipped vehicles)0.420.030.16 1980-1993 Federal Standard 7.000.412.00 1994-2003 Federal Standard 3.400.250.40 1997 ULEV Standard (California)1.700.040.20

Other advances in emissions control technology will add significantly to the air quality improvements promised by EHCs They include reformulated gasoline, introduction of electric and compressed natural gas vehicles, and advanced on-board diagnostics systems (OBDs) that provide real-time information about emissions performance, as well as fault tree data that can be downloaded for monitoring and repair purposes. A summary of these and other clean car innovations and policies, along with fuel economy measures, are provided in Table 2.

Fuel Economy

Given the enormous advances in vehicle design and emissions control technology, it seems reasonable to expect that similar advances have occurred in the fuel efficiency area. The fact is, however, that while major efficiency improvements have been achieved with experimental vehicles, the commercial and near-commercial applications of energy-efficiency for automobiles and, especially, trucks, have been disappointing by comparison. Average fuel efficiency of new American cars actually declined by 4 percent from 1988 to 1992." Fuel prices, unlike the price of clean air, have not figured prominently in discussions about vehicle design since the early 1980s although conflicts like the 1992 Gulf War served to remind many Americans that a fateful link -- oil -- still ties our foreign policy and transportation policy together.

Table 2

Green Car Technologies

Emissions Control*

electrically heated catalysts
remote sensing of emissions
oxygenated fuels
leak free exhaust/double wall pipes
improved fuel atomization
dual oxygen sensor compensation
palladium catalysts with cerium washcoats
on-board diagnostic systems
reformulated gasoline
alternative fuels
sequential fuel injection
vapor recovery systems
adaptive transient fuel control

Fuel Economy

use of composites in body molding recapture of braking energy hybrid electric drives aerodynamic design advanced radial tires

^{*}Many of the emissions control technologies may also help to improve fuel economy, just as some of the fuel economy measures may also offer emissions benefits.

The role of IVHS in helping to achieve energy conservation goals is based largely on the premise that smoothing traffic flows, finding the most efficient routes, and eventually providingautomated vehicle control systems, will reduce unnecessary VMT and improve actual on-road fuel economy for all classes of vehicles. Initial estimates of energy impacts of IVHS projected 6.5 billion gallons of fuel being conserved by the year 2010, however these estimates have been reduced substantially as additional induced demand factors have been considered." While some advocates of supercars are touting ultra-light hybrids that they claim will travel coast to coast on 8 gallons of gasoline, "the apparent demand for such vehicles is low. Since fuel costs represent less than 13 percent of the direct costs of driving, there is little incentive for travelers to make fuel economy a major consideration in their modal choices and vehicle purchases. Absent higher gasoline taxes, efficiency rebates (e.g., California's DRIVE+ program), greater political instability in oil-rich regions, or the imposition of stronger corporate fuel economy standards (CAFE), there is little reason to expect that fuel savings of future fleets will approach their emissions savings.

While several innovative pricing measures, such as pay-at-the-pump auto insurance, might have a significant salutary effect on both fuel economy and vehicle emissions, the political obstacles to such measures have so far been daunting."

TECHNOLOGY, POLITICS, AND MARKETS

It is customary in papers of this type to pause at this point in order to sharpen the contrast between the promise of new technologies, the dismal impedance of politics, and the redeeming pull of the marketplace. Only the power of the market, many believe, can rescue publicly regulated technoscientific triumphs from the mire of bureaucracy and interest group struggle A free market, in their view, is the best antidote to the paretic poison of modem politics. It seems to follow that only strong market forces can assure successful navigation of IVHS through the complex corridors of power and channels of public acquiescence. Idealistic environmental, energy, and equity concerns in such a setting are assumed to yield to the logic of the market as marginal costs and benefits -- those that can be easily measured -- are added and compared. Such perspectives lead many to view the implicit demands and constraints placed on IVHS by the Clean Air Act and other policies as excessive, even counterproductive. Why expect IVHS to solve air pollution problems that ought to be tackled by auto manufacturers and by designers of vehicle inspection and maintenance programs?

The above characterization arguably represents the conventional wisdom of many in the IVHS community. It does not, however, do justice to the complexity and significance of public policy making. Politically speaking, IVHS acceptance may ultimately depend less on drawing attention to the problems that it solves than on managing the problems that it amplifies. Americans confronted with a technology or a policy that takes them three steps forward for each step backward may nevertheless choose to emphasize losses over gains. Such behavior may seem irrational to many, but it is understandable to many social psychologists and experts on risk perception." In cases where the implementation of the technology or policy being considered is virtually a foregone conclusion, as with IVHS, the tendency to focus on problems rather than opportunities may grow even stronger. Given the decentralized, staged deployment process that IVHS will almost surely follow, there will be multiple intervention points and policy venues for those who wish to stop or slow implementation. As any activist knows, it is usually easier to block initiatives in our political system than it is to get them adopted. Those who believe that market forces will sweep away these islands of resistance would do well to remember the lessons of the American SST program or the RU 486 "abortion pill."

To some extent, IVHS represents a set of technologies in search of applications. But it could also be said that IVHS represents a set of disparate policy goals in search of integration. Environmental and other non-transportation objectives will have to play a major role in determining IVHS configurations and applications if substantial compliance with pre-existing goals and policies is to be achieved. In the policy arena, tails **do** wave dogs, especially when they are dogs (e.g., transportation) with multiple tails (e.g., air quality, access for the disabled, energy conservation, etc.). But this indicates a further problem with the conventional wisdom. It conceives of problems and solutions too narrowly. The remedy perhaps can be found in the emerging insights of sustainable transportation thinking, an alternative viewpoint that offers a much more integrated and collaborative approach to problem solving. The sustainability paradigm begins with a simple and, some say, simplistic goal: "[To meet] the

needs of the present without compromising the ability of future generations to meet their own needs."22 The test of a sustainable transportation technology is whether it is compatible in the long run with basic ecological precepts and collective human needs. Rather than drawing sharper distinctions between technology, politics, and markets, the approach of sustainable transportation is to recognize the interdependence of all three in forging long-term solutions to what are predominantly urban problems. As important as markets and trade are in shaping our future way of life, they are nevertheless derivatives of politics, and probably always will be. They cannot operate independently of politics anymore than Wall Street can separate itself from the actions of the Federal Reserve. Based on the premise that there is no such thing as a free market or free trade, only designed markets and designed trade, the central question becomes how to foster cooperation within and between business and government for the purpose of designing technologies, policies, institutions, and markets that will improve our quality of life. IVHS represents a test case for this kind of thinking, and the "greening" of IVHS, if indeed it occurs, will reflect a change in values every bit as important as the change in technology that it represents.

POLICY WEDGES

The analytical challenge of sustainable IVHS deployment is essentially one of optimizing across competing public policies for the purpose of minimizing the zone of incompatibility between stated or implied policy goals. Although the idea that official policies often work at cross purposes may sound like an indictment of the American policy making process, in reality, a certain amount of incongruity in policy objectives is unavoidable in political systems that depend on compromise and on the strategic use of ambiguity in coalition building. Our system being one that occasionally raises policy incompatibility to absurd heights (e.g., tobacco subsidies and anti-smoking programs), it should come as no surprise that intelligent transportation technology and intelligent transportation policy may sometimes follow different paths. Successful deployment of IVHS will require more of a reconciliation process involving multiple goals and objectives than a linear implementation process pegged to efficiency. Furthermore, given the interjurisdictional challenges of federalism, it will require a reconciliation of the interests of multiple agencies and levels of government, not to mention a profound reconciliation of the different cultures and customs that divide public and private sector actors.

In thinking about how to relate advances in vehicle emissions control and fuel efficiency to prospects for IVHS deployment, it is helpful to recognize three cross-cutting policy issues that link the goals of clean air, energy security, mobility, and access to transportation. The first is the growing preference for demand-side management (DSM) rather than supply-side management of public problems.23 The second, and related, issue is the growing reliance of governments on market-based tools for problem solving (and the concomitant erosion of command-andcontrol regulation).24 The third involves the application of technology-based solutions to problems that were previously thought to require fundamental changes in human behavior for their successful management. While achievements made possible by DSM, market-based tools, and technical fixes are often oversold or uncritically accepted (especially in the case of technical fixes), the unmistakable trend over the past decade has been nevertheless Applications of joint DSM-market incentive programs have toward greater reliance on these approaches. revolutionized energy and water resource management, for example, and seem poised, with the help of automatic vehicle identification (AVI) and road pricing, to offer the same kind of benefits for the management of transportation. Technological innovations, such as IVHS, heated catalysts, gas-sipping vehicles, and the information highway, promise large additional benefits that should ease the transition to more sustainable lifestyles and forms of development, despite some unforeseen and unintended consequences that are likely to be viewed negatively by some groups in society.25

Tying these three policy trends together in a way that assures broad political support and mutual gains is a matter of some urgency for the IVHS community. Without greater attention to the empirical bases for environmental, energy, and social concerns about IVHS, some members may make the mistake of assuming that public relations and education campaigns will overcome any negative images. A long list of failed efforts in this vein -- from nuclear power to chlorofluorocarbons -- reveals that control of the public agenda is often fleeting.26 A far more promising strategy may be to develop a common core of tools and objectives that treat environmental, energy, mobility, and transportation access issues in an interactive fashion, using sustainability as a design standard.

One approach worth considering would be to note the consistent patterns in policy design that are developing in each of these four issue areas. All reveal the same basic substitution trends whereby centralized, technology-forcing regulations and supply enhancement programs are slowly replaced by decentralized, market- and performance-based standards, and demand reduction programs. For reasons that will soon become obvious, I have termed this the "Wedge Strategy." Figure 2 depicts a rudimentary form of the wedge strategy as it might be applied to each of the aforementioned issues. Each wedge represents a policy instrument that is either growing or declining in use over time, Those showing growing reliance involve demand-side management, market-based tools, and green technology innovations. Those portrayed with a proportional drop in reliance are measures based on supply-side management and command-and-control regulation. The wedge strategy is merely a heuristic device for the present; something intended to help in the construction of conceptual frameworks with which to understand IVHS goal conformity. The point of the strategy is to recognize that IVHS will contribute positively to goal integration and conformity on multiple fronts if and when it is employed in the service of DSM, market-based pricing, and development of green vehicles.

Of the policy goals presented, equitable access may be the most difficult to achieve politically and economically. As an overconfident Werner von Braun once observed, technology has the potential to address all public problems except for equity and corruption. In the case of IVHS, addressing the equity problem may become easier as telecommunications substitutes for both work and nonwork-related travel become available for low-income households, but this will depend on progress achieved in other areas, such as the degree to which universal access is achieved in deployment of the super-information highway.

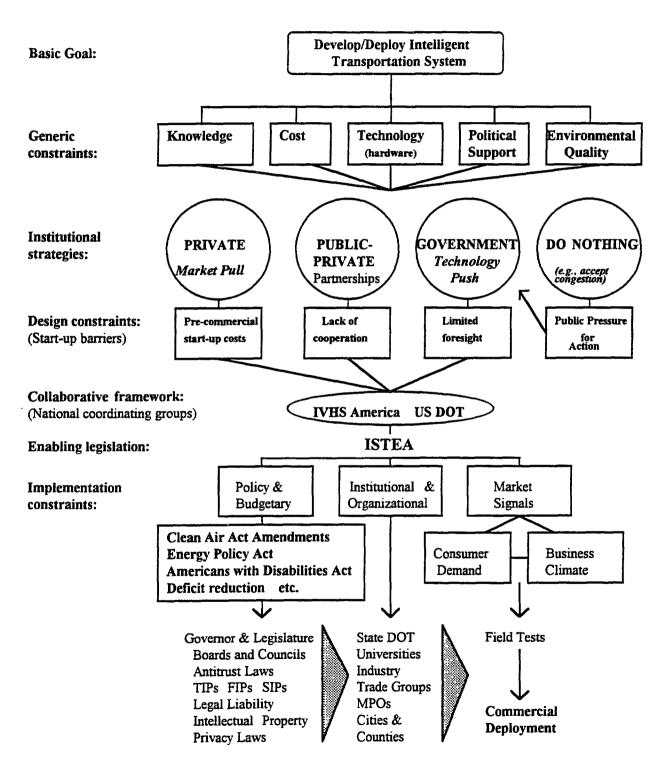
CONCLUSION

This paper has assessed the role of IVHS as an amplifier of emissions and fuel consumption characteristics of on-road vehicles. To a lesser extent, it has addressed equity issues that arise in the course of using IVHS to resolve conflicting policy goals in the transportation, environment, energy, and land use arenas. It is clear from the preceding discussion that reducing travel delay is desirable, with or without accompanying net reductions in vehicle emissions and fuel consumption (as long as there are no net increases). At the same time there is a growing suspicion on the part of many environmentalists that IVHS will be deployed primarily as a capacity enhancer, without accompanying growth management incentive programs. As such, it could justifiably be viewed as a "ratchet" policy that merely pushes back or defers many urban problems, while increasing their scale.

I have tried to demonstrate that advances in green vehicle technology provide strong reason for optimism about our future ability to increase the volume of vehicles, trips and miles traveled, while sharply reducing the levels of emissions and fuel consumption. The political will and market capability to introduce that technology appropriately and in a timely fashion is a matter for more sober consideration. If the current pace of political support and technological innovation continues, advances on the clean car front are likely to reduce concerns about emissions associated with IVHS capacity enhancement. Fuel economy concerns, on the other hand, will prove to be a more difficult challenge for IVHS designers, given current policies on automotive fuel efficiency and gasoline pricing.

Figure 1

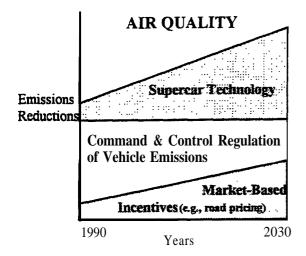
CONSTRAINTS MAP OF I.T.S. IMPLEMENTATION

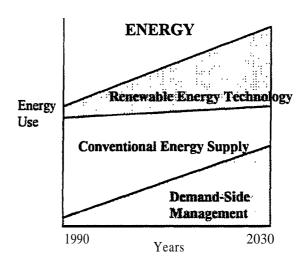


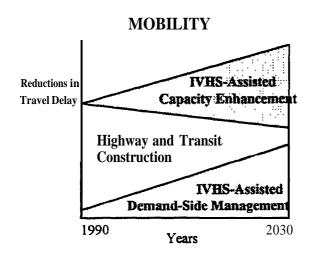
Hempel, 1994

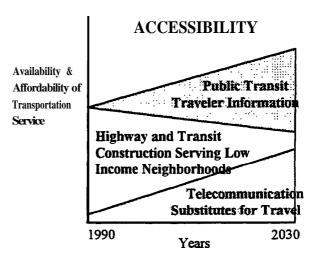
Figure 2

"Wedge Strategies" for Achieving Transportation-Related Policy Goals









ENDNOTES

- 1. Intelligent Vehicle-Highway Systems (IVHS) is used here in recognition of the technical transportation community's familiarity with and historical preference for the term. The author, however, prefers "Smart Access," or the term "Intelligent Transport Systems" (ITS). The reliance of IVHS on the words "vehicle" and "highway" has unnecessarily widened the gulf separating the concerns of many transportation professionals from those of environmental, energy, and community equity/access groups.
- 2. A doubling of capacity would probably require widespread use of AHS/AVCS technology. Depending on assumptions about transit use and the type and configuration of AHS/AVCS and other IVHS technologies, some analysts have suggested that even a tripling of capacity may be economically possible.
- 3. Harry W. Richardson (with Chang-Hee Christine Bae), "Brown Sky Blues: Are Transportation Rx's a Cure?" in *Resource Papers for the 1994 ITE International Conference*, Institute of Transportation Engineers, March 1994, p. 17.
- 4. The compliance cost to employers of the South Coast Air Quality Management District's ridesharing program (Regulation XV) in 1992 was estimated to be \$160 million. It was credited with eliminating approximately 54,000 vehicles from the road, making the cost per vehicle \$2,963. Generously assuming that each vehicle removed due to ridesharing was a super emitting vehicle, one could compare cost effectiveness by applying the \$2,963 to an on-road remote sensing and repair program in which it is assumed that 80 percent of super-emitters (representing 10 percent of all vehicles in use) are correctly identified and 80 percent of that number are successfully repaired or retired at an average cost of \$200 per vehicle. Assuming that the average test costs \$1 .OO per vehicle, a minimum of 14 super-emitters (from a tested field of 215 vehicles) would be successfully repaired or retired for each one that is removed by ridesharing (in reality, of course, only about IO percent of vehicles eliminated by rideshare programs are likely to be gross polluters, hence the cost advantages of abatement programs based on remote sensing are being understated in this example).
- 5. J. E. Moore, "Ridership and Cost on the Long Beach-Los Angeles Blue Line," *Transportation Research Annual*, 1993, p. 27.
- 6. Langdon Winner, *Autonomous Technology: Technics-out-of-control as a Theme in Political Thought* (Cambridge: The MIT Press, 1977), pp. 226-25 1.
- 7. The conformity requirements imposed by the Clean Air Act (CAA) amendments of 1990 are among the most important constraints affecting future IVHS deployment. But it is important to note that ISTEA, itself, is a powerful constraint on the way in which intelligent transportation technologies are utilized. It is, of course, also the principal enabling legislation for developing IVHS. The linkage of Air and Transportation policy is provided principally through the Congestion Mitigation and Air Quality Improvement Program (CMAQ) of ISTEA and the periodic review (joint EPA-DOT analysis) of transportation impacts on air quality required in Section 108(f)(3) of the CAA.
- 8. For a discussion of the concepts and potentials of Supercars, see Amory B. Lovins et al., "Supercars: The Coming Light-Vehicle Revolution" (Rocky Mountain Institute, 1739 Snowmass Creek Road, Snowmass, Colorado:81654-9 199, Publication T93-10, 1993).
 - 9. Jack Keebler, "Makers Look at Setting Trap for Emissions," Automotive News, July 27, 1992, p. 35.
- 10. Elmer Johnson, Avoiding the Collision of Cities and Cars: Urban Transportation Policy for the Twenty-first Century (Chicago: Academy of Arts and Sciences, 1993), p. 4.
- 11. Calculated on the basis of annual new passenger car registrations, 1960-1990, in World Motor Vehicle Data (Detroit: Motor Vehicle Manufacturers Association, 1992 edition).

- 12. Steve Nadis and James J. Mackenzie, Car Trouble (Boston: Beacon Press, 1993), p. 18.
- 13. A proposal to introduce vehicle speed governors is developed by Michael Replogle in "IVHS At Risk: A Review of Draft National Program Plan for Intelligent Vehicle-Highway Systems" (Washington, DC: Environmental Defense Fund, November 25, 1993).
- 14. Robert J. Farrauto, Ronald Heck, and Barry Seronello, "Environmental Catalysts," *Chemical and Engineering* News, September 7, 1992, p. 34.
- 15. California Air Resources Board, "Draft Discussion Paper: Low-Emission Vehicle Program Costs" (Sacramento, CA: March 25, 1994 CARB Workshop), Table 4. Note: 8 cylinder engines qualifying for California's ULEV standards are assumed to require a dual EHC system costing approximately \$285.
- 16. Data in Table 1 is taken from S. Albu, M.J. Heimrich, and M. Ahuja, "Electrically Heated Catalysts for Cold Start Emission Control," *Transactions of the American Society Of Mechanical Engineers*, July 1992, pp. 496-501.
 - 17. Steve Nadis and James J. Mackenzie, Car Trouble (Boston: Beacon Press, 1993) p. 18.
- 18. M. Cheslow, "Energy Estimates for the Years 2000 and 2010," Surface Transportation and the Information Age: Proceedings from IVHS AMERICA 1992 (Washington DC: IVHS America), Vol. I, pp. 404-412.
- 19. Amory Lovins, Presentation at the 1993 Conference on Transportation and Energy, Asilomar, CA (August 22-25). A summary is provided in the Winter 1994 issue of *ITS Review* (November 1993/February 1994) p. 6.
- 20. Advocates of "pay at the pump" no-fault auto insurance have been conducting a statewide initiative campaign in California to offer voters an alternative to the current system of auto insurance. They plan to have their initiative on the March 1996 ballot. Organized as the Coalition for Common Sense Auto Insurance, supporters claim that a 25-cents-per-gallon surcharge on gasoline, plus an annual vehicle registration fee of \$141 (\$9 1 for low income and senior citizens), would provide basic coverage for all California motorists, while reducing insurance premiums for most drivers by 30% to 40%. The initiative campaign has encountered heavy resistance from the state's trial lawyers and insurance industry, and is not expected to make it to the 1996 ballot with the pay at the pump provision in tact.
- 21. See, for example, Amos Tversky and Daniel Kahneman, "The Framing of Decisions and the Psychology of Choice," *Science* 211 (198 l), pp. 453-458; and Mary Douglas and Aaron Wildavsky, *Risk and Culture: An Essay on the Selection of Technological and Environmental Dangers* (Berkeley: University of California, 1982).
- 22. World Commission on Environment and Development, *Our Common Future* (London: Oxford University, 1987) p: 8.
- 23. Demand-side management generally holds that when scarcity and the cost of technological fixes for providing public services are greater than the costs of limiting demand for those services, governments should seek to reduce public demand through education, market incentives and, if need be, rationing.
- 24. For a general discussion of this trend, see David Osborne and Ted Gaebler, *Reinventing Government: How the Entrepreneurial Spirit is Transforming the Public Sector* (New York: Penguin/Plume, 1993) pp. 280-3 10. For a discussion focused on environmental and energy implications, see Robert Stavins and Bradley Whitehead, "The Greening of America's Taxes: Pollution Charges and Environmental Protection," *Policy Report* No. *13* (Washington, DC: Progressive Policy Institute, February 1992).

- 25. For example, market and technology innovations will be viewed by some as offering unwanted reprieves for a discredited car culture. It is difficult, however, to imagine voluntary behavior changes (e.g., widespread use of transit and ridesharing programs) that promise the same degree of benefits without assuming sweeping and unprecedented changes in human values and economic rationality.
- 26. See, for example, Frank R. Baumgartner and Brian D. Jones, *Agendas and Instability in American Politics* (Chicago: University of Chicago, 1993). A model for IVHS deployment that would obviously be more appropriate than that of nuclear power would be an environmentally sensitive and access-oriented version of U.S. commercial airline development. Being able to convince millions of people that they could move safely, affordably, and efficiently at 30,000 feet above the ground was no small feat. Convincing even more people that a diverse set of electronic, robotics, and information technologies will rescue their ground transportation systems from traffic "crawl" may require no less imagination and critical awareness.

ENERGY CONSUMPTION IMPLICATIONS OF TELECOMMUTING ADOPTION

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ABSTRACT

Telecommuting, advocated as a promising transportation management strategy, is intended to substitute a portion of physical commuting trips during peak hours by information flow, thereby reducing energy consumption and air pollution. This paper discusses the potential for energy savings from telecommuting and its implications for the transportation planning process.

Although several pilot telecommuting projects have demonstrated a reduction in commuting trips, a network-wide assessment has not been reported in the literature, partly due to the lack of mathematical models to predict telecommuting adoption. This paper applies recent telecommuting adoption models to predict adoption. The commuting trips substituted by telecommuting are then taken into account in the network-wide estimate of potential reduction in travel and energy consumption. Results suggests that about 14.5% of total workers in Austin will work from home about twice per week under a "salary neutral" program scenario; this is equivalent to 5.8% workers telecommuting every day and will save about 2.5% (18,400 gallons) of total fuel consumed by vehicles. The predicted values of telecommuting adoption in Dallas and Houston are 5.9% and 5.0% (on a everyday equivalent basis), and fuel savings are 2.6% (126,700 gallons) and 2.1% (94,400 gallons), respectively.

The estimation results also have implications for telecommuting program design. For example, the results confirmed that both employee participation and employer support are influenced by the economic implications of the program design. While employees are not willing to sacrifice salary to work from home, employers are not inclined to favor a program that decreases the telecommuter's salary, either, implying that a salary-neutral telecommuting program design may be acceptable to both employees and employers. In addition, both models reveal that the effect of changes in salary is stronger than responsibility for bearing additional telecommuting costs.

1. INTRODUCTION

Advances in information technology during the past decade have two primary types of implications for transportation planning strategies, with potentially significant impacts on environmental concerns such as energy consumption and air pollution. The first is intended to improve transportation system performance through the use of information technology, such as advanced traveler information system (ATIS) functions under the IVHS umbrella, where drivers are provided real-time network information to improve network utilization. The second, focusing on transportation demand management, is telecommuting, which is intended to substitute part of physical commuting trips during peak hours by information flow and therefore reduce energy consumption and air pollution. This paper discusses the potential energy savings resulting from telecommuting and its implications for the transportation planning process.

Although several pilot telecommuting projects on the west coast have demonstrated a reduction in commuting trips during peak hours, few attempts have been reported on estimation of aggregate impacts at the network level. For example, energy savings have been estimated primarily as the product of individual trip savings (due to telecommuting) and the average fuel consumption per trip. A network-wide assessment has not been

addressed in the literature, partly due to the lack of mathematical models to predict telecommuting adoption. This paper applies the results of telecommuting adoption models developed by the authors to predict adoption. Commuting trips substituted by telecommuting are then incorporated in a network-wide estimate of potential reduction in travel and energy consumption.

The interactions between telecommuting and its environment are discussed in the following section. Models of the telecommuting adoption process by employees and employers, respectively, are then presented along with their implications for telecommuting program design. The estimated models are used to predict the extent to which telecommuting will be adopted, a key determinant of the impacts of telecommuting on energy consumption and air pollution. The prediction then forms the input to a model to estimate network-wide travel and energy savings due to telecommuting. Additionally, telecommuting implications for the transportation planning process are discussed.

2. TELECOMMUTING AND ITS ENVIRONMENT

The interactions between telecommuting and its environment are illustrated in Figure 1, which indicates that telecommuting adoption, a joint outcome of employee and employer decisions, is influenced by four external factors: telecommunications technologies, transportation systems performance, public policies, and land use patterns. The consequences of telecommuting adoption typically include three different levels of impacts. Short-term impacts refer to changes in travel behavior and activity patterns of telecommuters. Medium-term impacts include household activity allocation and car ownership. Long-term impacts involve possible relocation of telecommuting households and offices of organizations.

Telecommuting is one of a range of telecommunications applications (e.g., teleconferencing and teleshopping) that have potential impacts on transportation and the environment. The availability of telecommuting is influenced by the penetration of telecommunications related facilities in the community of interest. In addition, increasing concerns over urban traffic congestion and air quality have heightened interest in telecommuting as a promising transportation demand management strategy. Other external factors, such as land use patterns and public policy also have a bearing on telecommuting adoption, primarily on employer decisions. Pacific Bell's first telecommuting program, for example, was initiated when the local government asked businesses to reduce traffic during the 1984 Summer Olympics in the Los Angeles area (Bailey and Foley, 1990). On the other hand, the Interactive System Corporation, a computer software company in Santa Monica, California, adopted telecommuting because it could not afford to lease an office (SCAG, 1985).

The impacts of telecommuting derive primarily from the changes in travel behavior (e.g. frequency, departure time, trip chaining) and activity patterns of the telecommuter. Some pilot projects indicate that such changes may also be experienced by household members of the telecommuting adopter (Kitamura *et al.*, 1990), as telecommuting households reallocate activities among members in order to adapt to the new work and travel pattern of the telecommuter. For example, a former commuter who usually drops a child off at school on the way to the office and purchases groceries on the way back home would no longer do so during telecommuting days, unless he/she makes morning and evening trips specifically for these purposes. These duties may be transferred to other household members who still drive to work, or the pattern of some activities (e.g. shopping), namely frequency, time of day, or day of week may change. The reallocation of household activities may interact with the relative priority of car use among household members and perhaps lead to a reduction of household car holdings.

The changes described above may also cause eventual reconsideration of household residential location, as well as organizational office location. A household might move closer to the workplace location of a non-telecommuting household member. Insufficient evidence is available to confirm the impact of telecommuting on household residential location. During a two-year telecommuting pilot project in California, about 50% of the respondents who either relocated or were considering it reported that telecommuting influenced their residential location decisions. However, a formal statistical test did not reject the hypothesis that household shift patterns are not significantly different between telecommuters and non-telecommuters (Nilles, 1991).

It is mainly the short-term and medium-term impacts (i.e., changes in travel patterns and activities at

individual and household levels) that affect transportation system performance. To the extent that work trips have been recognized as the major determinants of energy consumption by vehicles, the change in commuting travel behavior has a bearing on energy savings as well. Thus, the aim of this paper is to investigate network-wide energy savings due to the substitution of work trips by telecommuting.

3. TELECOMMUTING ADOPTION MODELS AND POLICY IMPLICATIONS

Tables 1 and 2 show the parameter estimation results of two models of telecommuting adoption by employees and employers, respectively. These models are based on an ordered-response formulation derived by the authors and estimated using employee and executive stated-preference data, respectively, obtained from three Texas cities (Austin, Dallas, and Houston) (Mahmassani *et al.*, 1993; Yen *et al.* 1994a, 1994b, and 1994c). The ordered-response model maps the range of a continuous latent variable onto a set of discrete outcomes. For a given decision situation, the latent variable represents the decision maker's perceived utility or attractiveness toward the decision object of interest (telecommuting in this research). A set of ordered thresholds for the latent variable associated with each decision maker define ranges corresponding to each discrete decision outcome. The decision-maker's choice then depends on the corresponding interval within which the perceived utility or attractiveness lies. In the present models, choice alternatives are ordered from lower preference for employee participating in and employer support for telecommuting to higher preference. It follows that for a given set of utility thresholds the greater value of the perceived attractiveness of telecommuting (the latent variable), the more likely are employees (or employers) to adopt telecommuting. On the other hand, for a given latent variable, the higher the thresholds are, the less likely are employees or employers to adopt telecommuting.

Readers interested in model development and specification are referred to other papers by the authors (Yen *et al.*, 1994b and 1994c). This section interprets the estimation results and their policy implications. Please note that only estimated coefficients of variables specified in the systematic components are indicated in the Tables; estimates of the variance-covariance structure aimed at capturing autocorrelation among observations are not shown.

With respect to the employee model, Table 1 shows that salary increase (S15) has a positive effect on the latent variable, and thus will increase the probability that employees choose telecommuting, for a given set of utility thresholds. On the other hand, the coefficients of salary decrease (SD5 and SD10) imply that employees are less likely to choose telecommuting if they have to sacrifice part of their salary. Similarly, responsibility for additional costs to work from home (ANL, BPC, and PART) negatively affects employee preferences, with all estimated coefficients being negative.

The relative magnitudes of estimated coefficients reveal useful information on employee preferences from the standpoint of program design and public policies. For instance, coefficients of SD5 (-1.3 1 1) and S15 (0.293) indicate that salary decrease exerts a stronger effect on employee preferences than a comparable increase. Additionally, the coefficients of both dummy variables for 10% salary decrease (-1.909) and 5% decrease (-1.3 11) confirm that the former has a stronger effect but suggest a non-proportional relationship between the amount of salary decrease and its influence on the latent variable, with a decreasing marginal effect of further salary decrease. Significant differences among the coefficients of variables ANL, BPC, and PART (-0.643, -0.901, and -0.807, respectively) indicate that requiring telecommuters to buy a personal computer (BPC) is a stronger deterrent to telecommuting than other additional cost items. The coefficients of SD5 and SD10 are statistically less than those of ANL, BPC, and PART, indicating that salary sacrifice has a stronger negative effect than having to acquire additional equipment. This finding has important implications on telecommuting program design for organizations willing to provide such work arrangement.

Other variables that exert positive effects on employee telecommuting adoption include number of children under age 16 (CHIL16) or personal computers at home (HOMEPC), employee computer proficiency (SKILL), number of hours in which employees use a computer on work each day (HRCOMP), distance from home to the workplace (DSTRIP), as well as employee attitudes toward job suitability for telecommuting (FJOBSU) and effect of telecommuting on family. Variables that have negative effects include amount of time employees need to communicate face-to-face with co-workers (HRFACE), average number of stops (STOPS) on commuting trips (a

proxy of employee activity pattern) and employee attitude toward the importance of social interactions with coworkers (FSOCIO).

Table 2 shows the estimation results of the employer adoption model parameters, based on stated preference information supplied by executives and managers. As expected, employer responsibility for some (ES) or all (ET) additional telecommuting costs has a negative effect on executive preferences. Similarly, the negative coefficient of variable S15 indicates that an increase in the telecommuter salary reduces the probability that executives will support such a program, all else being equal. Interestingly, a decrease in telecommuter salary (SDS) also exerts a negative influence on executives' willingness to support telecommuting, indicating that a program that reduces telecommuters' salary will not necessarily increase the likelihood of executive support. This result might be contrary to the *a priori* speculation that executives would support any program that could cut the organization's costs. Executives undoubtedly believe that it would be unfair to penalize a telecommuter if he/she could have the same job performance, and that reducing telecommuter salary would not be viewed favorably by employees, and would therefore lead to a poor public image of the organization.

The relative values of the coefficient estimates of S15 (-1.03 1) and SD5 (-0.676) indicate that an employee salary increase exerts a stronger negative effect on executive support than a decrease. Though executives may not wish to decrease the telecommuter salary, they find it less tolerable to increase telecommuting employee salary. As expected, the significant difference between the coefficients of ES (-0.414) and ET (-0.572) indicates that the executive is less inclined to support a program when the organization incurs all rather than only part of the additional costs. The results also imply that an increase in telecommuter salary is less tolerated by executives than having to assume some or all telecommuting costs.

Other variables that affect executive telecommuting adoption include educational achievement (EA), job title (JT), management span (SOM), awareness of telecommuting (AW), as well as attitudes toward the effect of a telecommuting program on data security, the performance and morale of telecommuting workers, and management concerns such as executive work load and ability to supervise telecommuters.

The models presented in this section provide a methodology for predicting telecommuting adoption, which in turn forms the basis for predicting trip reduction and fuel savings potential of telecommuting, as described next.

4. IMPACTS OF TELECOMMUTING ON ENERGY SAVINGS

Four methods have been used previously to estimate fuel savings from telecommuting. The first calculates fuel savings as the product of the average fuel efficiency and average number of miles saved from each telecommuting occasion. The second takes into account differences among individual vehicles and aggregates individual savings, obtained from self-reported fuel efficiency and reduced travel distance due to telecommuting. The third method goes a step further to consider trip characteristics that influence fuel efficiency, including travel speed and whether it is a cold or hot start (Handy *et al.*, 1993). None of the three methods considers network effects in the estimation of energy savings.

The fourth method, developed by Sullivan *et al.* (1993) and used in this paper, relies on the "two-fluid model" of traffic in an urban network (Herman and Prigogine, 1979), which provides a macroscopic network-level description of traffic interactions in a network. It is used in this analysis to translate the fractions of vehicular trips substituted by telecommuting into total savings in vehicle-miles traveled (VMT) in a network. Fuel savings are then calculated based on a calibrated fuel consumption model. The two-fluid model takes into account network attributes such as average speed, concentration, and directional factors. The procedure also recognizes the possible increase in speed experienced by non-telecommuters that continue to commute.

To assess fuel savings due to telecommuting, it is essential to predict the extent to which telecommuting will be adopted. Recognizing that telecommuting adoption is the joint outcome of employee and employer decisions, both models presented in the preceding section are used. Since the probability of employee participation is conditional on the provision of such a program by employers, the probability of joint adoption is the product of

the conditional probability of employee participation and the marginal probability of employer support. Because employees apparently do not want to sacrifice salary in order to telecommute, and employers are generally disinclined to increase telecommuters' salary, the reasonable program scenario for the prediction of possible telecommuting adoption is the one under which telecommuters' salary remains the same. Detailed procedures for aggregate telecommuting prediction are given elsewhere by the authors (Yen et al., 1994d). Table 3 lists the separate and joint predictions for employees and employers in three Texas cities under the program scenario with neutral telecommuter salary and employers incurring all additional telecommuting costs (such as a new phone line).

For employee participation, results in Table 3 are intended to represent possible adoption by the target group of potential telecommuters, namely information related workers. To facilitate aggregate prediction, the population of information workers is stratified into two groups of employees: those having computer proficiency at the medium or high level as group 1, and others as group 2. The composition of groups | and 2 are obtained from the telecommuting survey sample (83% vs. 17%, 87% vs. 13%, and 83% vs. 17% for Austin, Dallas, and Houston, respectively). The values of exogenous variables specified in the estimated adoption models used in the prediction are obtained through the following rationale. First, it is assumed that the distributions of variables such as commuting attributes and the number of children under 16 among members of the target group is the same as the whole population. Therefore, the former are based on surveys with random observations in Texas (Jou*et al.*, 1992), and the latter is based on the U. S. census data (1990). Finally, other job attributes for the target group are based on information from the telecommuting survey conducted to calibrate the adoption models.

Predicting employer adoption is fraught with even greater uncertainty, especially with regard to the characteristics of the population of pertinent decision-makers in information-related organizations. Recognizing this uncertainty, employer adoption is predicted under three alternative scenarios: optimistic, middle, and conservative, as illustrated in Table 3, reflecting different composition of the underlying executive population. For aggregate prediction, the population of "representative" decision makers is conveniently stratified into two groups. Members in group 1 do not hold titles of president or vice president, have a management span of less than 6, and possess awareness of telecommuting. Members in the second group hold president or vice president titles, with management spans of at least 6 subordinates, and are not aware of telecommuting. The optimistic scenario assumes that the population of representative decision makers for employer adoption consists of 80% in group 1, and 20% in group 2. The population compositions for the middle and conservative prediction scenarios are 50% vs. 50% and 20% vs. 80%, respectively. Employee adoption (conditional on employer sponsorship) is assumed to be the same across the three prediction scenarios for each city. For each scenario, while employee adoption is predicted by city to reflect differences in transportation system performance and demographic data in the three cities (Table 4), employer adoption levels are assumed to be the same in the three cities. Under the optimistic scenario, about 42% of information workers in Austin will choose to work from home about twice per week, with 42% and 36% for Dallas and Houston, respectively. These probabilities decrease to 29%, 29%, and 25% for the middle scenario, and 16%, 17%, and 14% for the conservative scenario, respectively.

To predict fuel savings due to telecommuting the middle scenario prediction is used as the base case. According to Woods and Poole (1990), 50% of total workers are information related in these cities. Assuming that telecommuting occasions are uniformly distributed across five work days per week, the predicted percentage of total workers who work from home every day is equivalent to 5.8% in Austin, 5.9% in Dallas and 5.0% in Houston, respectively, as listed in Table 5. These equivalent percentages of telecommuters are then applied to predict networkwide fuel savings due to telecommuting using the method proposed by Sullivan *et al.* (1993). Table 5 shows that predicted adoption of telecommuting will save about 18.4 thousand gallons of gas in Austin per day, 126.7 thousand gallons in Dallas, and 94.4 thousand gallons in Houston. These savings are equivalent to 2.53%, 2.62%, and 2.08% of the total fuel consumed by vehicles every day in each city, respectively. Table 5 also indicates that vehicle fuel savings during peak hours (7-9 A.M. and 4-6 P.M.) on arterial are 3.6 thousand gallons in Austin per day, 23.3 thousand gallons in Dallas, and 22.0 gallons in Houston, which are equivalent to 5.73%, 6.17%, and 5.05% of total fuel consumed by vehicles everyday in the peak on arterial in each city, respectively. As expected, results reveal that fuel savings in terms of percentage in peak are higher than on the daily basis.

To reflect the variation of fuel savings according to different levels of employer adoption, which is believed

to play a relatively more important role than employee adoption to date, fuel savings are also predicted under the conservative and optimistic prediction scenarios. In Austin, the conservative prediction indicates an equivalent 3.3% telecommuting penetration every day, resulting in 1.44% savings of daily fuel, or 3.26% fuel savings in peak hours. These numbers increase to 8.3%, 3.62%, and 8.19% under the optimistic scenario, respectively. Overall, the equivalent telecommuting penetration under the conservative scenario is about 3.0% in the three cities, 5.5% under the middle scenario, and 8.0% in the optimistic case. In terms of fuel consumed, daily savings range from about 1.5%, 2.5%, to 3.5% under three different prediction scenarios. Peak savings are about 3.0%, 5.5%, to 8.0%. The results show that fuel savings highly depend on the level of employer telecommuting adoption, and suggest that executives may need to be targeted by public policy makers to promote telecommuting acceptance and penetration.

5. SOME TELECOMMUTING IMPLICATIONS FOR TRANSPORTATION PLANNING

The implications of telecommuting on the transportation planning process can be illustrated in Figure 2. Conceptually, the aggregate travel demand on transportation systems derived from each individual's activities motivates capacity addition to the transportation infrastructure and/or policy measures to manage the resulting congestion. These changes in the transportation system influence the land use pattern in the community, which in turn affects individuals' activities. Empirically, in order to predict travel demand and the associated performance of the transportation system, traditional transportation planning procedures use different types of land use models to predict future economic activities in the area of interest. The results of land use models and demographic data then provide the input to the four-stage transportation planning process intended to project the performance of the transportation system for the particular land use pattern under consideration (Manheim, 1979; Paquette *et al.*, 1982; Meyer and Miller, 1984).

Although a plethora of critiques of the traditional four-stage procedure can be found in the literature, it remains well entrenched in transportation planning practice. Recent policy concerns such as air quality, congestion management and advanced technologies have led to renewed interest in alternative transportation planning methodologies. In practice, activity-based approaches to travel demand analysis appear particularly attractive. Their basic premise is that activity and trip patterns rather than individual trips should be at the center of demand analysis procedures. Activity-based approaches are particularly appropriate to analyze the transportation impacts of telecommunications technology applications. The latter can directly and indirectly influence activity patterns as they have the potential to transform the movement of people and goods on transportation networks by information transmission.

The development of telecommunications technologies may affect land use patterns and hence the economic and social activity system. For example, Kutay (1986) argued the importance of communication networks as a determinant of office location, paralleling the role of transportation systems in regional economic development (Adler, 1987). To the extent that telecommunications networks might be a substitute for transportation systems in the future, they may be expected to play a role in the growth of economic activities and spatial distribution of industry. Thus businesses today with high information-related activities may be located where easy access to telecommunications networks is available (Salomon. 1988).

The impacts of telecommuting on transportation system performance are due to the substitution of commuting trips by information flow. The reduction of travel ultimately mitigates traffic congestion and air pollution. It has long been recognized that transportation infrastructure improvements tend to generate additional demand for travel that is attracted by better service levels (Adler, 1987). Therefore, it may not be unreasonable to expect at least part of the potential savings from telecommunications applications to be offset by induced demand. Additionally, the impacts of telecommuting on activity patterns at the individual and household levels have been discussed in section 2. As a result, the implications of telecommuting on transportation planning have to be recognized through its impacts on land use, activity, and transportation systems. Finally, policies and regulations enacted by the public sector may target telecommunications technologies, the transportation system. or the land use pattern. Intervention by governments is primarily on the supply side of these factors, and may include control of pricing and level of service. Such supply side actions will affect demand side as well.

6. CONCLUSION

This paper predicts potential savings in fuel consumption resulting from telecommuting in three cities in Texas. The prediction procedure relies on the "two-fluid model" of traffic in urban networks, and calculates fuel savings based on a calibrated fuel consumption model. Results indicate that for the middle prediction scenario about 14.5% of total workers in Austin will work from home about twice per week under the salary neutral program, which is equivalent to 5.8% workers telecommuting every day, and will save about 2.5% (18,400 gallons) of total fuel consumed by vehicles per day. The predicted portions of telecommuting adoption in Dallas and Houston are 5.9% and 5.0% (on a everyday equivalence), respectively. Fuel savings are 2.6% (126,700 gallons) and 2.1% (94,400 gallons), respectively. However, alternative prediction scenarios reflect considerable uncertainty regarding the levels of employer adoption and support of telecommuting, suggesting that executives form a critical target group for public policy action aimed at encouraging telecommuting.

The above prediction is based on two models of telecommuting adoption by employees and employers, respectively, and a set of assumptions to derive reasonable values for the explanatory variables from exogenous data source. The estimation results also have policy implications in terms of telecommuting program design. For example, estimation results found that both employee participation and employer support are influenced by economic implications of the program design. Specifically, both changes in employee salary and the costs incurred by telecommuters (or employers) significantly influence these two decision makers' adoption decisions. While employees are not willing to sacrifice salary to work from home, employers are not inclined to institute programs that decrease the telecommuter's salary, either. In addition, both models reveal that the effect of changes in salary is stronger than the responsibility for assuming additional telecommuting costs. The results imply that a salary-neutral telecommuting program design may be acceptable to both employees and employers.

While the fuel consumption savings potentially achievable through telecommuting are meaningful, they are not likely to be the primary motivation for greater telecommuting adoption and support through public policy. Ultimately, it is the benefits that both employees and employers might derive in terms of enhanced lifestyle options and eventually greater productivity that will determine the degree of penetration. Employees benefit from the decrease in the time and cost spent commuting, and the resulting increase in discretionary time and scheduling flexibility. Employers benefit by reducing overhead cost of offices and employee turnover. It is only incidental that society also benefits through reduced congestion and fuel consumption savings.

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Table 1. Estimation Results of Employee Telecommuting Choice Model

Variables	Variables Parameter 1		
	n the latent variable		
Constant		-0.190	
(Economic	implications)		
SI5:	Change in telecommuter salary (1 if increase 5 %; 0 otherwise)	0.293	(30.0)
SD5:	Change in telecommuter salary (1 if decrease 5 %; 0 otherwise)	-1.311	(-4.9)
SD10:	Change in telecommuter salary (1 if decrease 10 %; 0 otherwise)	-1.909	(-9.8)
ANL:	Additional phone costs assumed by employee		
	(1 if need to add a new phone line at home; 0 otherwise)	-0.643	(-3 1 .0
BPC:	Additional computer costs assumed by employee		
	(1 if need to buy a personal computer; 0 otherwise)	-0.90 1	(-7.3)
PART:	Additional partial costs assumed by employee		
	(1 if need to pay part of the costs; 0 otherwise)	-0.807	(-8.9)
(Employee	personal and household characteristics)		
CHIL16:	Number of children under age 16 at home	0.142	(3.2)
HOMEPC:	Number of personal computers at home	0.202	(9.6)
SKILL:	Index of computer proficiency		
	(1 if at least one skill at medium or high level; 0 otherwise)	0.272	(16.0)
	job characteristics)		
HRFACE:	Number of hours communicating with co-workers		
	face-to-face per day	-0.344	(-18.0)
HRCOMP:	Number of hours using a computer on work per day	0.175	(17.0)
	commuting attributes)		
DSTRIP:	Distances from home to the workplace, miles	0.028	(15.0)
STOPS:	Average number of stops on the way to work and		
	back home per week	-0.124	(-14.0)
	n the utility thresholds		
Utility thre	shold 2		
Constant		2.270	
FJOBSU:	Regression score of employee attitudes toward job	0.40.5	
	suitability for telecommuting	-0.436	(-33.0)
FFAMIL:	Regression score of employee attitudes toward		(2 4 0)
Egogto	telecommuting effect on famil	-0.577	(-3 1 .0)
FSOCIO:	Regression score of employee attitudes toward the importance of social interactions with co-workers	0.568	(14.0)
Utility thre			()
Constant	SHOIU 5	2.864	
FJOBSU:		-0.318	(21)
FFAMIL:		-0.318 -0.126	(-3.4)
FSOCIO:		-0.126 0.820	(-2.0)
		0.820	(8.4)
	observations 545 ood value at zero -5228.7		
	ood value at zero -3226.7 ood value at convergence -3909.0		
Log likelille	ood value at convergence -3707.0		

^{*} Numbers in parentheses are t-values

Table 2. Estimation Results of Employer Telecommuting Choice Model

Variables Estimates*		Parameter	
Specified i	n the latent variable		
Constant	in the latent variable	0.229	
	implications)	0.22	
SI5:	Change in telecommuter salary (1 if increase 5 %; 0 otherwise)	-1.031	(-3.5)
SD5:	Change in telecommuter salary (1 if decrease 5 %; 0 otherwise)	-0.676	(37.0)
ES:	Employer responsibility for partial additional telecommuting		(= , , ,
	costs (1 if some costs; 0 otherwise)	-0.414	(-32.0)
ET:	Employer responsibility for all additional telecommuting costs		()
	(1 if total costs; 0 otherwise)	-0.572	(-22.0)
	personal characteristics)		
EA:	Executive's educational achievement	0.402	(12.0)
	(1 if a master or Ph.D. degree; 0 otherwise)	0.493	(12.0)
AW:	Awareness of telecommuting	0.525	(10.0)
	(1 if the executive knows someone who telecommutes; 0 otherwise)	0.537	(19.0)
(Executive	job characteristics)		
JT:	Executive's job title (1 if president or vice president; 0 otherwise)	-0.772	(-38.0)
SOM:	Number of subordinates directly supervised by the executive		,
	(1 if <= 5; 0 otherwise)	0.451	(23.0)
~			
	n the utility thresholds		
Utility thr	esholu Z	3.923	
Constant FTELE:	Regression score of executive attitudes toward	3.923	
FIELE.	telecommuting effect on telecommuters and		
		-0.488	(-60.0)
EMANO.	public image of the organization Regression score of executive attitudes toward	-0.400	(-00.0)
FMANG:	the management impacts of telecommuting	-0.118	(-22.0)
	the management impacts of telecommuting	-0.110	(-22.0)
Number of	observations 80	_	
Log likelih	ood value at zero -791.0		
Log likelih			

^{*} Numbers in parentheses are t-values

Table 3. Predicted Probabilities of Telecommuting Adoption for Information-Related Workers

	Predicted Choice					
Joint	Employer	Employee	Probabilities			
			Optimistic Scenario			
.417	.64 1	.650	Austin			
.42 1	.641	.657	Dallas			
356	.64 1	.556	Houston			
			Middle Scenario			
.290	.446	.650	Austin			
.293	.446	.657	Dallas			
.248	.446	.556	Houston			
			Conservative Scenario			
.163	.25 1	.650	Austin			
.165	.25 1	.657	Dallas			
.140	.251	.556	Houston			

Table 4. Mean Values of Explanatory Variables Used for Telecommuting Prediction

Variables		Austin	Dallas	Houston
Specified in	the latent variable			
(Employee p	personal and household characteristics)			
CHIL16:	Number of children under age 16 at home	0.64	0.71	0.82
HOMEPC:	Number of personal computers at home	0.56	0.53	0.48
(Employee j	ob characteristics)			
HRFACE:	Number of hours communicating			
	with co-workers face-to-face per day	1.56	1.44	2.17
HRCOMP:	Number of hours using a computer			
	on work per day	4.48	3.90	3.91
(Employee	commuting attributes)			
DSTRIP:	Distance from home to the workplace, miles	10.80	13.00	13.90
STOPS:	Average number of stops on the way			
	to work and back home per week	4.25	4.10	4.92
Specified in	the utility threshold			
FJOBSU:	Regression score of the employee's attitudes			
	toward the job suitability for telecommuting	3.98	3.90	4.29
FFAMIL:	Regression score of the employee's attitudes			
	toward the effect of telecommuting on family	2.65	2.38	2.67
FSOCIO:	Regression score of the employee's attitudes			
	toward the importance of social interactions			
	with co-workers	3.42	3.33	3.38

Table 5. Fuel Consumption Savings from Telecommuting Under Realistic Network Data (Conservative Scenario)

Austin Dallas Houston							
	C	M	0	C	M 0	C M	0
portion of total workers working							
from home twice per week (%)	8.2	14.5	20.9	8.3	14.7 21.1	7.0 12.4	17.8
equivalent portion of total workers							
working from home everyday (%)	3.3	5.8	8.3	3.3	5.9 8.4	2.8 5.0	7.1
fuel savings, thousand gallons per of	day 10.	.5 18.4	26.3	71.1	126.7 180.4	52.7 94.4	132.2
fuel savings, percentage (%)	1.44	2.53	3.62	1.47	2.62 3.73	1.16 2.08	2.91
fuel savings, gallons, peak on arterial	2.1	3.6	5.2	13.0	23.333.1	12.3 22.0	31.2
fuel savings, percentage (%), peak on arterial	3.26	5.73	8.19	3.45	6.17 8.78	2.83 5.05	7.17

Prediction scenarios:

C, conservative

M, middle

0, optimistic

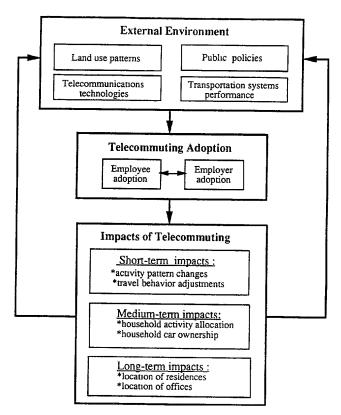


Figure 1. Interaction between Telecommuting Adoption Process and External Environment

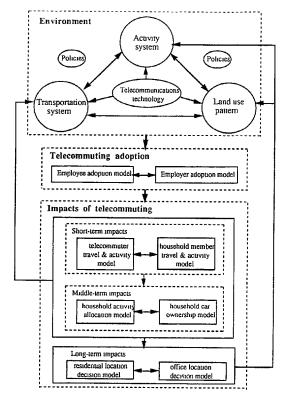


Figure 2. Implications of Telecommuting on Transportation Planning

CARBON MONOXIDE IMPACTS OF AUTOMATIC VEHICLE IDENTIFICATION APPLIED TO VEHICLE TOLLING OPERATIONS

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INTRODUCTION

Intelligent transportation technologies (ITT's) are being promoted as a means of reducing congestion delay, improving transportation safety, and also as a means of making vehicle travel "...more energy efficient and environmentally benign (USDOT, 1990)" In theory, IVHS technologies will increase the efficiency and capacity of the existing highway and roadway systems to reduce congestion (Saxton and Bridges, 1991; Conroy, 1990; Shladover, 1991; Shladover, 1989). We are not confident, however, that vehicular emissions will be reduced by the full range of proposed ITT's.

The transportation-air quality community has in the past lacked the appropriate tools in which to predict the effects of microscopic changes to vehicular activity induced by ITT's. The currently used emissions models, EMFAC in California, and MOBILE in the remainder of the US, are unable to provide the resolution needed to quantify the effects of these changes. Research at UC Davis is focusing on estimation of a statistical 'modal' model capable of simulating the emissions impacts from individual vehicles under various operating scenarios. The emissions model, currently a significantly modified version of the mathematical algorithms employed in the CALINE 4 Line Source Dispersion Model developed by Paul Benson and others at Caltrans (Benson, 1989), predicts emissions based upon individual vehicle speed-time profiles and laboratory measured emission rates. The model, therefore, can quantify vehicular emissions under various ITT scenarios.

This paper examines the carbon monoxide (CO) emission impacts of one such applied ITT, namely Automatic Vehicle Identification (AVI) used to implement automatic tolling. AVI used in lieu of conventional toll booths has previously been identified as an ITT that is likely to offer air quality benefits (Washington, Guensler,& Sperling, 1993a). By allowing vehicles to be tolled either through a windshield displayed debit card, or by some other mechanism, vehicles could forgo the deceleration, stop-delay, and ensuing acceleration that results from an encounter with a conventional tolling station. The results presented here are preliminary, and represent the beginning stages of an ongoing research effort. More substantial and complete results will be provided as they become available.

BACKGROUND

The six basic ITT "technology bundles" (Jack Faucett Associates, 1993) include: Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Advanced Vehicle Control Systems (AVCS), Commercial Vehicle Operations (CVO), and Advanced Public and Transportation Systems (APTS). Each of these technology bundles is designed to achieve the same general goal; improve the efficiency of the transportation system through the application of communications and computational technologies. However, the efficiency objectives targeted by each technology bundle are distinctly different, and will have different potential effects upon the parameters that effect vehicle emissions (Washington, Guensler, Sperling, 1993a).

Previous research has concluded that one of the most likely technology bundles to improve air quality is Advanced Traffic Management Systems (Washington, Guensler, Sperling, 1993b). As the name implies, ATMS employ computer control technologies to 'optimize' or smooth traffic flows on a transportation network. Examples of ATMS technologies are real-time traffic signal network optimization, real-time ramp metering, and automatic vehicle tolling via automatic vehicle identification technologies (AVI). These computer controlled systems are

designed to reduce congestion levels; minimize system-wide delay levels, and generally smooth vehicular flows. ATMS technology bundles also include various signal actuation bundles, incident detection, rapid accident response, and integrated traffic management.

Automatic toll collection, the topic of this paper, aims to smooth traffic flows by implementing advanced communications technologies between roadway and vehicles. If conventional tolling operations performed on bridges or tolled turnpikes were replaced with automatic and transparent vehicle identification and debiting, for example, then toll plaza delays experienced by motorists could be eliminated. The elimination of these activities would further result in fewer declarations, idling, and acceleration events prevalent under conventional tolling operations. These 'modal' activities, representing high load and power conditions, have been shown to contribute significantly to the production of emissions from motor vehicles (LeBlanc, et al., 1994; CARB, 1991; Benson, 1989; Groblicki, 1990; Calspan Corp., 1973a; Calspan Corp., 1973b; Kunselman, et al., 1974). In fact, one sharp acceleration may cause as much pollution as does the entire remaining trip (Carlock, 1992). This suggests that a small percentage of a vehicle's activity may account for a large share of it's emissions (LeBlanc, et. al., 1994). In addition, longer enrichment events are more highly correlated with large emission excursions than are shorter events (LeBlanc, et. al., 1994) and furthermore, deceleration events are capable of producing significant emissions (Darlington, et al., 1992). In contrast to cold start emissions that occur over a period of minutes, acceleration and deceleration related emissions occur over a period of a few seconds.

Using a preliminary 'modal' model that accounts for relative contributions of CO emissions from acceleration, deceleration, cruise, and idle events, we assess the impacts of automatic tolling using AVI. The goal is to quantify the expected CO emission differences between a toll-plaza and AVI scenario. In addition, the expected variation in these benefits is approximated given current limitations of the vehicle emissions data. The results provided represent preliminary research findings, and will be supplemented with further findings when they become available.

DESCRIPTION OF THE MODAL MODEL

The preliminary 'modal' model employed in these analyses is a derivative of the CALINE Line Source Dispersion Model that has been developed over many years by the California Department of Transportation (Benson, 1989). The model is different from the CALINE model in several very important respects. First, individual vehicle 'FTP BAG 2' (Washington, Guensler, and Sperling 1994) emission rates are used in the model. rather than an 'approximated' average values applied to the vehicle fleet. Second, individual idle emission rates are used in the model, rather than 'approximated' average values applied to the vehicle fleet. Finally, the 'dispersion' portion of the CALINE model is not employed, but rather, only the algorithms used to determine the emissions inventory are used. These differences result in a statistical model that can explain approximately 70% of the variation in emissions for individual vehicles tested on 14 different emission testing cycles. This is in comparison to both the current EMFAC and CALINE models, while employing fleet average FTP Bag 2 and idle emission rate values, explain about 13% and 2% of the variation in emissions for individual vehicles respectively (Washington, Guensler, and Sperling, 1994).

The latest version of the CALINE4 model is similar to the Colorado Department of Highways (CDOH) model released in 1980. The data used to estimate model coefficients were derived from 37 discrete modes driven by 1020 light-duty vehicles ranging from 1957 model year to 1971 model year. In both the Caltrans and CDOH model development efforts, a strong relation was noted between modal emissions and the average acceleration speed product (AS) for the particular acceleration mode. Consequently, AS is one of the explanatory variables used in the CALINE4 model (Benson, 1989).

The CALINE4 model is descriptive and not deterministic. This means that the model is estimated using observed emissions and vehicle behavior, rather than using more causal variables such as fuel volatility, cylinder size, mechanical efficiency losses, etc. The model employed in this research effort is identical to the functional form contained in CALINE model, except for the significant and important differences noted earlier (and described below).

The modified CALINE model can be written as:

$$TE_{ik} = EI_{ik} + EA_{ik} + EC_{ik} + ED,$$
, where;

TE_{ik} = Total CO emission estimate for vehicle i on cycle k in grams,

 EI_{ik} = CO emissions from idle events for vehicle i on cycle k in grams,

 $E\ddot{A}_{i,j}$ = CO emissions from acceleration events for vehicle i on cycle k in grams,

 $EC_{i,j}$ = CO emissions from cruise events for vehicle i on cycle k in grams,

ED,, = CO emissions from deceleration events for vehicle i on cycle k in grams.

The emission contributions from modal events are defined as:

$$EI_{ik} = (IR_{fgrams/sec1}) * (t_{f/secs1})$$
, where;

IR is the measured individual vehicle idle emission rate, t_i is time in the idle operating mode.

$$EA_{ik} = [(FTPB2_{ferans/mint}) * (C1) * EXP (C2 * AS)] * t_{a | frees|} * 1_{fmint} / 60_{free}], where;$$

FTPB2 is measured emission rate on FTP Bag2 for individual vehicles,

Coefficients Cl = 0.75 and C2 = 0.0454 for acceleration condition 1,

Coefficients Cl = 0.027 and C2 = 0.098 for acceleration condition 2,

AS is the acceleration speed product based upon average speed and average acceleration rate of the accel mode, Acceleration condition 1 is for vehicles starting at rest and accelerating up to 45 mph,

Acceleration condition 2 is for vehicles starting at 15 mph or greater and accelerating up to 60 mph, ta is the time in the acceleration mode.

$$EC_{ik} = (FTPB2_{[gram \lor min]})) * [(0.494 + 0.000227 * S_{[mph]})^{2}]] * (t_{c_{[Necs]}} * I_{[min]} / 60_{[sec]}, where;$$

FTPB2 is measured emission rate on FTP Bag2 for individual vehicles, t_r is the time in the cruise event.

$$ED_{ik} = (IR_{fgrams/sec1}) * (t_{dfsecs1})$$
, where,

IR is the measured individual vehicle idle emission rate, t, is time in the deceleration operating mode.

The modified CALINE model is used in conjunction with summed emissions from steady-state modal events for a vehicle on any cycle. For example, a given speed-time trace is parsed into discrete model events of idle, cruise, acceleration, and deceleration. The emissions from these events are then summed over the cycle to obtain the total emission estimate.

EXPERIMENTAL DESIGN

To estimate the difference in CO emissions between a vehicle encountering a conventional toll plaza, and the 'no delay' experience by automatic vehicle identification tolling operations, the modified CALINE model is employed. To perform these comparisons, a toll plaza is first simulated on a typical transportation link. The link could be a typical tolled bridge entrance, or could be the entrance to a tolled freeway. The toll plaza design follows that described by Lin (1994), representing a Gate type 'C' operating at level of service A. Under these conditions, the average vehicle experiences about 6 seconds of delay waiting for previously queued vehicles (Lin, 1994). Since the emissions estimates from vehicles encountering toll plazas are done on a per-vehicle basis, and because level of service A is assumed in these initial analyses, the traffic volume is not important (congestion delay induced by toll plazas and high traffic volumes will be covered in subsequent analyses).

To simulate vehicular activity under the two different scenarios, speed-time profiles were developed four different vehicle trajectories. Table | displays some characteristics of these speed-time profiles. Two speed-time profiles were developed for vehicles entering a toll plaza, one for drivers exhibiting 'aggressive' driving behavior and one for drivers exhibiting 'normal' driving behavior. All vehicles were assumed to begin and end their speed-time trajectory at a speed of 60 mph (other speeds will be covered in subsequent analyses). Aggressive driving

Table 1. Characteristics of Assumed Vehicle Speed-Time Profiles Under both Toll-Plaza and AVI Scenarios

Cycle	Maximum Acceleration	Length of Cycle	Distance of Cycle	Deceleration Time in seconds	Acceleration Time in seconds
Description	Rate (mph/sec)	(seconds)	(miles)	(60mph to Omph)	(60mph to Omph)
Toll Plaza,					
'Aggressive'	4.5	37	0.249	14	15
Driving					
Toll Plaza,					
'Normal'	2.0	66	0.517	30	30
Driving					
AVI,					
'Aggressive'	1.0	15, 31	0.249, 0.5 17	n/a	n/a
Driving					
AVI,					
'Normal'	0.5	15, 31	0.249, 0.5 17	n/a	n/a
Driving					

includes acceleration and deceleration rates of about 4.5 mph/sec, while normal driving includes acceleration and deceleration rates of 2 mph/sec. These rates agree with current car following and instrumented vehicle research that has substantiated acceleration and deceleration rates as high as 6 mph/sec (Cicero-Femandez, et. al., 1993).

Two more speed-time profiles were developed for the non-toll plaza scenario. Again, one for drivers exhibiting 'aggressive' driving behavior and one for drivers exhibiting 'normal' driving behavior. In the former case, aggressive drivers 'floated' around their 60 mph target speed by 3 mph with | mph/sec maximum acceleration and deceleration rates. 'Non-aggressive' drivers were assumed to 'float' around their 60 mph target speed by 1 mph with 0.5 mph/sec maximum acceleration and deceleration rates. Both of these cycles were 'length corrected' so cross-comparisons could be made between all categories of driving.

A BASIC computer program was used to 'parse' cycles into discrete modes of acceleration, deceleration, cruise, and idle (see Washington, Guensler, and Sperling, 1994). The program is also used to apply the modified CALINE algorithms to estimate the CO emissions estimates from generated speed-time profiles.

All of the vehicles contained in the current Speed Correction Factor Data Base (see Guensler, 1994) were used to estimate CO emissions from a 'fleet' of vehicles passing through the toll plaza and AVI scenarios. After several outlying test results were discarded, 436 remaining vehicles were used to approximate the vehicle fleet. The appropriateness of the vehicle fleet represented will be treated in subsequent analyses.

Since the modal model can predict CO emission contributions from acceleration and deceleration events, the resulting emissions predictions reflect the effect of microscopic traffic flow adjustments under the two different scenarios. The results of the modeling runs can be seen in Table 2. The model predicts that 'aggressively' driven vehicles will emit about 52 fewer grams of CO with AVI (on average) than with a toll-plaza. The median difference is about 11 grams of CO, which suggests that the distribution of CO emissions from this fleet of vehicles is non-normal and heavily skewed by influential 'dirty' vehicles. The standard deviation under the same scenario, about 123 grams, illustrates the extreme influence of these high emitting vehicles.

Table 2. Carbon Monoxide Emission Prediction Differences Between Toll Plaza and AVI Scenarios

Driving Behavior with	Driving Behavior with	Mean Carbon Monoxide	Median Carbon Monoxide	Standard Deviation in Carbon Monoxide
Toll-Plaza	AVI	Difference (grams / vehicle)	Difference (grams / vehicle)	Difference (grams)
Aggressive	Normal	53.68	11.04	127.10
Aggressive	Aggressive	51.67	10.59	122.66
Normal	Normal	12.17	2.97	27.85
Normal	Aggressive	8.03	1 .87	18.52

The table also illustrates that 'normal' driving behavior, i.e. vehicle activity incorporating moderate acceleration and deceleration rates, results in much smaller CO emission rate differences. These findings agree with current literature that has identified high emission rates with extreme modal activity.

DISCUSSION

These findings suggest that a large reduction in CO emissions can be realized through the application of an Intelligent Transportation Technology (ITT). This limited scenario, the replacement of conventional toll plazas on a freeway link with automatic vehicle identification technologies to debit passin g vehicles, has been previously identified as an application of ITT's with likely benefits to air quality. If we could implement this scenario for 6 months on a freeway segment, for example, with an average daily traffic volume of 15,000 vehicles per lane, in approximate numbers we could expect a reduction in CO emissions from about 33 to 140 metric tons per lane. The uncertainty in these estimates, however, need to be addressed.

Although it is a significant improvement over currently employed models in terms of individual emissions estimations, the statistical model employed here still needs improvement and refinement. This research is currently underway at UC Davis.

The representativeness of the vehicles contained in the Speed Correction Factor data set are not likely to be representative of the current vehicle fleet (Guensler, 1994). There are several methods in which to approach this deficiency. Subsequent analyses will incorporate a random sampling scheme, which will provide a means to mimic actual sampling from the real-world population of vehicles (from an emissions standpoint). Furthermore, we need to test new vehicles and sample the existing fleet to determine which fleet characteristics are truly 'representative'.

The impact of high-emitting vehicles and aggressive driving behavior is extremely important in these analyses. Subsequent analyses will address this effect, and will try to quantify the influence these vehicles and activities have on estimated emissions.

We need to look at many different implementation scenarios. Different approach speeds need to be considered, as well as different levels of congestion. In the above analyses, congestion is assumed not to exist, but practical experience shows that toll plazas are generally bottle-necks during peak periods, and we need to consider these congestion effects on emission estimates. We will address some of these issues in subsequent analyses.

Finally, we need to address the behavioral changes that might be induced by application of ITT's. For example, previous peak-period congestion induced by toll-plazas, now eliminated by application of automatic tolling using AVI, might make the travel route more attractive to motorists. If this short-term increase in peak period level of service attracts 'new' motorists to the facility, then the projected emissions reductions may be partially or fully offset by increased traffic and congestion.

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EVALUATING THE IMPACT OF IVHS TECHNOLOGIES ON VEHICLE EMISSIONS USING A MODAL EMISSON MODEL

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The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herin. The contents do not necessarily reflect the official views or policies of the State of California. This report does not constitute a standard, specification, or regulation.

ABSTRACT

One of the key goals of Intelligent Vehicle/Highway Systems (IVHS) is to improve mobility through the reduction of traffic congestion and increased throughput on today's road network. As congestion decreases and traffic flow is smoothed, associated air quality should improve. However, roadways with improved mobility and better throughput may induce an increase in traffic, resulting in a negative air quality benefit. In order to determine the impact of IVHS on air quality, models must be developed that can: 1) accurately predict vehicle emissions reductions due to smoother traffic flow; and 2) predict the induced demand for roadways when their throughput is increased due to IVHS. We are currently developing and applying a set of transportation/emission models in addressing this first issue. Current emission inventory models (e.g. MOBILE, EMFAC) simply relate vehicle emissions to average traffic densities and speeds on a specific network, and are not adequate for analyzing traffic at the microscale level required for IVHS evaluation. However, by using transportation simulation models that can accurately simulate dynamic vehicle activities (e.g., accelerations, decelerations) and integrating this information with detailed modal emissions models, precise emissions inventories for various IVHS scenarios can be achieved. Using a power demandbased modal emission model, we are currently evaluating total vehicle emissions associated with Automated Highway System (AHS) designs. Preliminary results indicate that with AHS's approximate four-fold increase of capacity, emissions will increase over current manual conditions by a factor of two if the system is used at full capacity (-8000 vehicles/hour-lane), stay the same at half capacity (-4000 vehicles/hour-lane), and will decrease by half at current traffic volumes (-2000 vehicles/hour-lane).

INTRODUCTION

Two central research questions pertaining to air quality exist for IVHS: Potential vehicle emission reductions through the application of advanced technology, and potential induced traffic demand.

Potential Vehicle Emission Reductions

IVHS has the potential to reduce vehicle emissions through several of its "technological bundles" (see, for example, reference I for an overview of IVHS). Advanced Vehicle Control Systems (AVCS) implemented at the vehicle level are intended to safely smooth traffic flow on the roadways by minimizing the stop-and-go effect of vehicles in congestion, and increase overall throughput. The heavy acceleration and deceleration components of vehicle trips can be eliminated, minimizing energy consumption and associated emissions of these vehicle operating modes. Advanced Traffic Management / Information Systems (ATMIS) will allow dynamic re-routing to take place on the roadway network, minimizing congestion and subsequently emissions. Further, navigational systems will allow users to reduce unnecessary driving and will aid in trip-chaining practices.'

Potential Induced Traffic Demand

In contrast, the implementation of some IVHS technologies may lead to an increase of total vehicle miles traveled (VMT). If IVHS allows smoother flow and higher speeds on the roadways, people may choose to live farther away from work while still commuting in the same amount of time-thereby increasing VMT. Farther, attractive trip-ends will become reachable, again increasing VMT. Further, advanced navigational technology may divert travelers from higher-occupancy modes such as buses and carpools to single-occupant vehicles. In general, if travel becomes easier due to advanced technology, VMT will likely increase.

In order to determine the impact of IVHS on air quality, significant improvements must be made in traffic simulation and travel demand models by closely integrating vehicle emission models. Existing traffic, emissions, and planning models have been developed independently of each other and are difficult to integrate together when determining accurate air quality impacts. Current emission models (i.e., MOBILE, EMFAC³) functionally relate emissions to average vehicle speed and density, and are not appropriate for analyzing IVHS scenarios. Under IVHS conditions, the dynamic behavior of vehicles will be very different compared to today's traffic conditions, upon which the current emissions models are based. As a result, *modal emissions data* (i.e., emissions data associated with vehicle modes, e.g., idle, acceleration, cruise. deceleration, etc.) should be used with microscale traffic simulations to obtain more realistic results.

In this paper, a power demand-based vehicle emissions modeling approach is first described, followed by a discussion of its application to evaluate emissions associated with automated highway system designs.

POWER DEMAND-BASED VEHICLE EMISSIONS MODELING

Second-by-second emissions data that are registered with vehicle dynamic operation are often referred to as modal emissions data -- emissions data that correspond to a vehicle's operating mode, e.g., acceleration, deceleration, steady state cruise, idle, etc. Using modal data in an emissions model is in sharp contrast to the current driving cycle-based emission inventory techniques (i.e., the Federal Test Procedure, FTP⁴), where emissions are collected in bags over long periods of time (on the order of 500 seconds), and then analyzed as a whole.

Second-by-second emissions data can be combined with an analytical model of the instantaneous power requirements placed on a vehicle's engine. A vehicle's acceleration performance (in the longitudinal direction) is limited by the engine power and the traction limits on the drive wheels. Given the instantaneous power requirements placed on a vehicle (at the wheels) for it to move depend on three types of factors: 1 *j Environmental factors* (e.g., mass density of air, road grade), 2) *Static vehicle parameters* (e.g., vehicle mass, rolling resistance coefficient, aerodynamic drag coefficient, cross sectional area), and 3) *Dynamic vehicle parameters* (e.g., commanded acceleration, and velocity). Given these parameters, it is possible to first determine the demanded tractive power, as shown in Figure 1. Further, the power demand on the engine can be determined by modeling the power transfer through the vehicle's drive system and incorporating other variables such as use of accessories (e.g., air conditioning, power steering).

One of the most important aspects of this power demand-based method for estimating emission output is modeling the vehicle's emission control system. Modem vehicles have complex emission control systems that include as the primary component a catalytic converter. An electronic engine controller regulates the air-fuel ratio to the engine so that the ratio is as near as possible to the stoichiometric ratio where the catalytic converter operates most efficiently. During normal operation of the vehicle, the air-fuel ratio is kept at the stoichiometric ratio (lambda = 1). However, there can be cases when the conversion efficiency of the emission control system is reduced. One example is during cold-start events, when the catalytic converter is not at its proper operating temperature and thus is not operating at its peak performance. Another important example includes power enrichment events. When a vehicle has a high engine power demand (which may be induced by a hard acceleration or steep grade), it has been shown that the emission control system can go "open-loop" and the air-fuel ratio is commanded rich for peak demand power and protection of engine components. Recent studies have shown that power enrichment events can contribute significantly to overall emission production. eg.5, 6,7 As a first approximation to modeling power enrichment events,

a simple thresholding technique is used. When the demanded engine power exceeds a particular threshold, the emission control system goes into an open-loop state, and the air-fuel ratio is rich, producing significant emissions. When the demanded power is below that threshold, the system maintains the air-fuel ratio at stoichiometry, resulting in low emissions. The emission output of carbon monoxide (CO), hydrocarbons (HC), and oxides of nitrogen (NOx) can be measured and correlated to demanded engine power induced under numerous operating conditions. The emission output can then be approximated by a function that relates emission species output to demanded power.

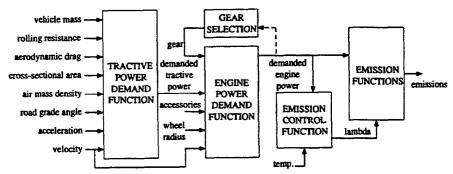


Figure 1. Load-Based Modal Emissions Modeling Methodology.

For use in our traffic simulations, the vehicle dynamics equations and load-based emissions were calibrated to a 1991 Ford Taurus, using data received from Ford Motor Company. As further modal emission data becomes available for other vehicles from Ford and other sources, they can easily be incorporated into this type of model when determining a more complete, comprehensive emission inventory.

AUTOMATED HIGHWAY SYSTEMS

IVHS technology in the form of AVCS can be applied to control vehicle motion so that vehicles can operate in "platoons," i.e., follow each other very closely at high speeds, while still maintaining a high safety margin. This has several implications: 1) traffic flow will increase dramatically over current highway conditions due to denser traffic traveling at higher speeds; 2) congestion should decrease since the stop-and-go effect caused by relatively long human reaction delays will be eliminated and accidents will be minimized.

Current highway traffic (i.e., uninterrupted traffic flow) can be characterized by the traffic volume (v), average vehicle speed (S), and vehicle density (D). These terms are generally related by the product. Further constraints operate on these parameters which restrict the type of flow conditions on a highway link. The general form of these constraints is shown in Figure 2, which illustrates some key points of uninterrupted traffic flow:

Zero rate of flow occurs in two distinct cases: 1) when there are no vehicles on the roadway, and 2) when the density is so high that all vehicles are stopped and can not move. In the first case, the density is zero, thus the flow rate is zero, and the speed in this case is assumed to be the driver's desired speed (i.e., vehicle free speed). In the second case the density is at its maximum and the vehicle speed is zero. The density at which this occurs is called the jam density.

- As density increases from zero, the traffic flow increases due to the increased number of vehicles. The average vehicle speed is reduced to maintain safety during higher density conditions.
- Traffic flow is maximized at a specific critical density. As density increases above the critical density point, speed drops off at a faster rate. Traffic flow tends to become unstable in this region due to perturbations from lane change maneuvers, merging, or any external variables (e.g., debris in roadway, accident in adjoining roadway, etc.). These perturbations can create disturbances that are not damped or dissipated in the flow. These unstable, forced flow regions in the curves are characterized by stop-and-go congestion.

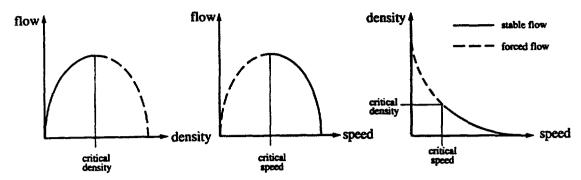


Figure 2. Flow, Density, and Speed Relationship of Traffic Flow.

Human driver flow-density-speed relationships can be approximated mathematically by specifying the headway, or gap, between vehicles required for safe stopping if one car suddenly brakes, and after a time lag, the second car also brakes without collision. The lower flow-density curve in Figure 3 was produced for the case when the first car brakes at 0.9 g (8.82 meters/second²) and the second car brakes at 0.6 g (5.88 meters/second²) after a one second time lag. This curve (after [9]) is for a single lane and is similar to curves predicted by the Highway Capacity Manual.⁸

A similar mathematical formulation can be developed for the flow-density-speed characteristics of an automated highway system. Within a platoon of vehicles, the headways are much smaller, closely regulated by automated controls. Therefore, platooned vehicles can travel faster at higher densities, thus improving the traffic throughput. Again, if we consider a single lane of platooned traffic as shown in Figure 4, we can mathematically approximate the flow-density-speed characteristics.

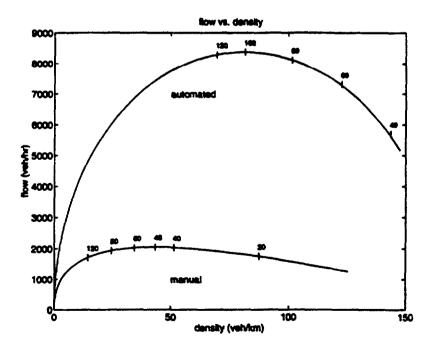


Figure 3. Flow-Density Relationship of Traffic for Both Manual Driving and Automated Driving. Velocity Values (km/hr) are Annotated on the Curve.



Figure 4. Platoons of Vehicles on a Highway.

Using the notation given in Figure 4, the vehicle density for an automated lane is given as: The interplatoon headway is determined as before, i.e., requiring safe stops if one platoon suddenly brakes, and after a time lag, the second platoon (leader) also brakes. In the automated scenario, the time lag is much shorter than for human behavior. The upper flow-density curve in Figure 3 was produced for the more restrictive case when the first platoon brakes at 2 g (19.6 meters/second'), and after a 0.3 second time lagthe second platoon (leader) brakes at 0.3 g (2.94 meters/second²). It is assumed that the intraplatoon headway is precisely controlled and can also perform safe stops under these specified stopping conditions. In the mathematical formulation, the intraplatoon spacing is set to one meter, the car length is five meters, the number of vehicles in each platoon is 20 vehicles, and the vehicle free speed is 120 km/hr. The difference between these two curves is substantial. The maximum traffic flow for the automated case is roughly four times that of the manual drivingcase. The maximum flow for the automated case occurs at an average speed of 103 km/hr, and for the manual case it occurs at 48 km/hr.

STEADY-STATE VEHICLE EMISSIONS

Emissions produced by traffic (manual or automated) will depend on several factors. In general, large variations in velocity (i.e., numerous acceleration, deceleration events) lead to higher emissions, therefore to minimize total emissions, traffic should be kept as smooth as possible. In this preliminary analysis, we only consider steady-state vehicle speeds and the associated emissions.

Using the power-demand emissions model described above, several microscale platoon simulations were carried out to determine average emission rates at different steady-state velocities. The motion parameters, engine power demand, and associated emission rates were calculated for each modeled vehicle in the simulation. Because the follower vehicles within a platoon have very small intrapiatoon headways (e.g., on the order of one meter), the aerodynamic drag coefficient of each follower is significantly reduced due to the "drafting effect". Using preliminary aerodynamic drag reduction data for vehicles in platoons, $\mathbb N$ the calculated power demand on the engine is significantly smaller at higher speeds. Based on the data, even the lead vehicle of a platoon has its aerodynamic drag coefficient reduced due to the vehicle following closely behind. A comparison between constant velocity CO emission rates' for 20 vehicles that are platooned and non-platooned is shown in Figure 5. In both cases the traffic density is low, and the vehicles are traveling near their free speeds. It is apparent that 20 vehicles traveling independently with no interaction have greater emissions at higher velocities than platooned vehicles that benefit from the drafting effect.

In order to determine total steady-state emissions of an automated lane within an AHS, these emission data were applied to the flow-density curves shown in Figure 3. It is important to note that the curves in Figure 3 reflect traffic density and flow associated with specified safe headways. Thus to generate flow values at lower densities, vehicle speeds greater than the free speed (i.e., the maximum speed a driver will go on the freeway without interference from other traffic) were used in the calculations. For purposes of generating total link emissions at lower densities, the flow values were adjusted so that the vehicle velocities at low densities were at the constant free speed.

^{*} Results of hydrocarbon (HC) and oxides of nitrogen (NOx) emissions also were obtained for all the experiments and are to the CO emissions and are not presented here due to limitations in space.

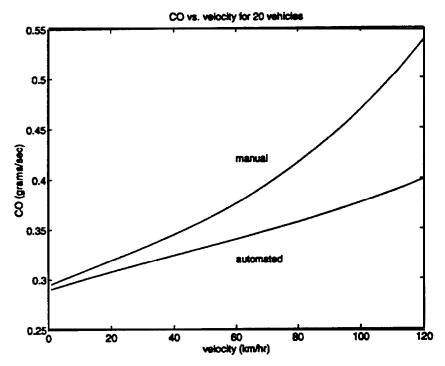


Figure 5. Constant Velocity Carbon Monoxide Emission Rates for 20 Vehicles Platooned and Non-Platooned.

The total CO emissions for a one kilometer lane are shown as a function of traffic flow for both the manual and automated (platooning) cases in Figure 6. There are several key points to note in this figure:

- 1) The maximum traffic flow for a manual lane is 2053 vehicles/hour at a average vehicle speed of 48 km/hour. At the same traffic volume, the automated lane produces roughly half as much emissions as in the manual case (manual: 0.76 grams/second, automated: 0.34 grams/second).
- 2) Given the emissions rate for maximum manual traffic volume of 0.76 grams/second, roughly *twice* the traffic volume can occur in the automated lane to produce the same amount of emissions (manual: 2053 vehicles/hour, automated: 4565 vehicles/hour at 0.76 grams/sec).
- 3) The maximum traffic flow for an automated lane is 8286 vehicles/hour at an average speed of 103 km/hour. The associated emissions at this point is roughly *twice* that of the maximum flow rate of manual driving.

It is important to point out that the emissions associated with higher traffic densities and lower average speeds are underestimated in these curves. Remember that these emissions are calculated based on steady-state velocities, and the negative slope region of the flow-density curve is inherently unstable, leading to stop-and-go traffic. The accelerations associated with stop-and-go traffic will lead to a greater amount of emissions.

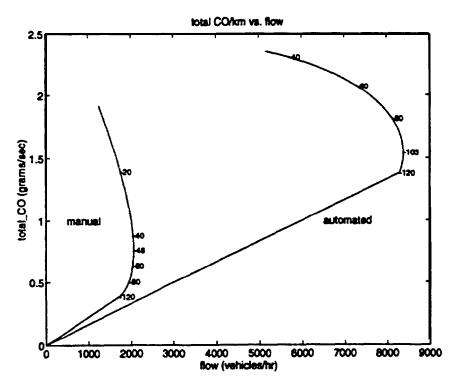


Figure 6. Total CO Emissions Versus Traffic Flow for Manual and Automated Traffic, for a One Kilometer Lane.

CONCLUSIONS

Based on microscale simulation models and modal emissions data for a modem, closed-loop emission controlled vehicle, steady-state (i.e., constant velocity) emission rates have been estimated for both manual and automated lanes. An automated lane using platooning can improve the traffic flow by a factor of four, and at maximum flow values, the total emissions increase is by a factor of two. If only half of the automated lane capacity is used, the traffic flow improves by a factor of two, and the associated emission rates are roughly the same as the full-capacity manual case. If the automated lane carries the same traffic volume as in the manual case, the emissions are reduced by a factor of two.

This analysis ignored transient emissions, i.e., emissions due to accelerations and decelerations associated with unstable traffic flow. We are currently using our models to predict the emissions associated with stop-and-go traffic in the unstable traffic flow-density regions. If congestion is to be avoided, the traffic should be kept in the positive slope region of the flow-density curve (see Figure 3). When in the positive slope region, interaction between vehicles in traffic is minimal, leading to smoother traffic flow. It can be seen that the extent of the positive slope region is much greater for the automated lane when compared to the manual lane.

This analysis assumed a constant platoon size of 20 vehicles, however, platoons will vary in length due to vehicles dynamically entering and leaving platoons as they travel from their specific origins to destinations. Shorter length platoons will lead to lower automated lane capacities and higher average vehicle emissions. Also, emissions associated with platoon maneuvers such as *splitting* and *merging* have not been analyzed here, but is currently under investigation.

Finally, the emission rates used in this analysis were for a single vehicle. For current manual driving, the vehicle population is quite varied, and to more accurately predict total emissions, emission rates for different vehicle classes must be incorporated. For an automated scenario, however, the vehicle population will be somewhat more restricted. Vehicles that have automated platoon technology will tend to be newer passenger vehicles with closed-loop emission control systems, similar to the vehicle modeled here.

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III. Socio-Economic Issues

INTELLIGENT TRANSPORTATION SYSTEMS Building Consent for Post-Cold-War Transportation Initiatives

Peter Roudebush and Harry Mathews

ABSTRACT

The authors analyze the inertia confronting private and public policy makers in America as the country transitions itself from Cold-War to peacetime government and business strategies. Calling attention to business practices now being deployed by multi-national corporations, and procedures being promulgated by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the authors trace the legacy of Cold-War policies and how public/ customer reactions have changed. In business sectors adapting to the transition, focused customer-supplier-fabrication-operations, just-in-time management practices and other business systems are now successfully reducing costs, minimizing risk, increasing productivity, and guiding cost avoidance programs. These practices are showing promising results and are beginning to influence transportation decision-making. These practices fundamentally change the role of government from directly initiating business top-down (as in war), to the no-less-demanding role of assuring communication and quality control for the initiation of new enterprise from the public, its customers, suppliers, and "the factory floor," bottom-up (as in peace). Essential to these practices is the flexibility to allow systems to change and adapt from the single-purpose values of war to the multiple values of peacetime activities. Similar practices are now being mandated of transportation decision makers through the metropolitan planning guidelines of ISTEA.

The authors point out that the short-term, single value, central product focus of past Cold-War policies caused both private business and government programs to become unsustainable by rewarding combative, non-competitive business procedures and eliminating flexibility. They note Cold War programs were based upon abstract, idealistic goals, condoning a disregard for consequences (don't think about the future) to achieve short-term (military) goals. The failure to adapt to change and the failure to look ahead eventually caused past practices to lose credibility as conditions and understandings changed from war, to the environment, to economic, health and social progress. The authors point out that recent history has provoked a widespread presumption that progress necessarily demands combative disagreement. They note that inertia, bolstered by this presumption, has raised the cost of productivity to unprecedented heights, stifled new enterprise, and exacerbated fear of change. They argue that more flexible, realistic, and accurate visions of future choices emerge as constructive circumstances for their nurture are implemented.

The authors suggest that *informed* constructive public participation can allay cynicism and restore vision to transportation planning, construction, and operation, by addressing externalities which are otherwise taken for granted. They cite the Boston Transportation Planning Review (BTPR) of 1972 to illustrate a procedure which addressed the formulation of a regional transportation master plan twenty years ago, using the founding principles of American democracy, directly making a plan "of, by and for the people." The BTPR process achieved enthusiastic political consent for a locally initiated *intermodal* regional metropolitan transportation plan. They explain how the BTPR's success resulted from open, informed discussion between interdisciplinary professionals and the public over the detailed consideration of multiple combined and integrated short and longterm values. This resulted in an imaginative, workable and practical plan appropriate to Boston's specific needs.

During the twenty five years in which participatory planning processes have been required by the National Environmental Protection Act, they have helped the public recognize the economic, social and environmental transitions essential to changing to a post Cold War economy, and revealed new collective ways to discover new peacetime economic activities imaginatively. The authors recognize, however, that participatory processes are not widely understood. They therefore detail the components of the BTPR example to assist the reader, who wants to compare it to other participatory processes with which he or she is familiar, by providing an outline in the appendix of the planning guidelines which made the BTPR successful.

The paper argues that public participation is an essential integral component of post-Cold War transportation systems, and that public/employee consent and participation are fundamental to sustainable (democratic) government and business decisions. They further also describe how emerging technologies combined with open discussion, through which ongoing and real time information may be widely networked and evaluated, can restore faith in post-Cold War public and private decisions, confidence in the long-term integrity of these decisions, and lead to the discovery of new sustainable, affordable and intelligent transportation systems.

INTRODUCTION

It's the Summer of 1945, you call a friend in a small town in Vermont (Summer population 3000) and your call is transferred to where he is having dinner, because the town telephone operator is everyone's friend and often has been told or has heard where her subscribers are planning to be. Today, if you call Area code 617-951-1433 in Boston, you'll hear "Good Morning, you have reached the Boston Society of Architects (population 11, not all full time)." "This is our user-friendly voice mail system. Please bear with me and I'll guide you where you wish to go. If you have a rotary or crank phone hold on, we can handle that too. If you know the extension of the person you want, push that extension now and I'll vanish. If you don't know their extension, push the pound or star key."

Does voice-mail answering really help your business? Does this technology save you and your client time and money? Is the value of that time more or less commensurate with what you would pay a receptionist? Should your business communications be entrusted to a machine or to someone answering the telephone?

The telephone operator who connected the caller with my father was doing something everyone thought normal in 1945. The country was at war. Everyone was helping one another (and the country) in a time of stress. People were planting their own vegetables; car-pooling to save gas; and helping one another cope with every imaginable problem. Today this feeling of cooperation seems to have disappeared. Many people seem to think, it can only exist in time of war. But these feelings were evoked in peacetime around a transportation planning event which occurred twenty years ago. This may be a model for achieving consent for intermodal transportation systems today.

The planning event took place in Boston in 1971, and became one of the intellectual cornerstones of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The Boston Transportation Planning Review (BTPR) was an enormously successful transportation planning experiment in public participation, which spontaneously conceived a locally initiated Metropolitan Area Intermodal Transportation Plan.

The BTPR was successful because its open public participation was integrated with broad interdisciplinary professional expertise. This allowed the public and the experts to explore transportation investment options together in detail. This enabled informed debate and the creation of common solutions. The review formulated holistic solutions no single person nor group could have conceived independently as accurately or as richly. It was not only a planning exercise, but an educational experience. Its results instilled deeply felt confidence on the part of everyone who participated. Participants sincerely felt their recommendations fully addressed their mandate carefully and accurately. The BTPR set the agenda for transportation planning for the Boston region for the next twenty years and has been followed with little controversy ever since.

The BTPR found out where Boston's constituency wanted to go, and organized a plan leading in that direction. We will describe this process in more detail. It indicates one way seamless intermodal transportation could be achieved today. Such systems depend upon people *wanting* them, wanting them to work, and wanting to work together to conceive, implement and operate them. The BTPR did that. But this kind of planning is not unique; similar techniques are now being used by major international corporations. These same techniques are helping businesses and manufacturers plan and build a myriad of post-Cold War facilities, tools and systems for a sustainable future.

THE BOSTON TRANSPORTATION PLANNING REVIEW

In 1969, Massachusetts officials were having trouble acquiring public consent for an Interstate Highway

"Inner Belt" for the Boston Region. Governor Francis Sargent instigated a review of the situation. The resulting BTPR, directed by Alan Altshuler, was designed with the help of Lowell Bridwell, former Federal Highway Administrator and representatives of state agencies, cities and towns, and interested citizens of the region. The review addressed a full spectrum of cross disciplinary criteria and interests including economics, social, environmental, historical, and landuse values, and urban as well as transportation design.

The BTPR's participatory process was very carefully constructed, and even began as the design for the study was being devised. Participation was made central to the actual planning taking place and made an integral part of it. No one was barred from participating. A special "Community Liaison" work element was separately funded to emphasize this and to help translate the concerns of interested citizens in case their contributions were not clearly understood by the professional team.

Citizens and experts saw their suggestions incorporated into the plan or amended as work progressed, perceived differently or accomplished through other means. Everyone who worked with the plan as it evolved were thus able to understand its implications. As a result, everyone connected to the plan - citizens, professionals and politicians - genuinely felt its product represented their own informed and considered opinions, hard work and self criticism. Their interaction generated mutual respect and even sometimes admiration. Ideas emerged which transcended groups or persons; it was extraordinary what wit and imagination came from voices which theretofore had been silent, including those of staid, well-seasoned engineers, who thought it not their place to make suggestions, nor that they might ever have an opportunity to do so even if they had a good idea.

Participants viewed themselves not as decision-makers, but as advisors to the Governor and the body-politic, providing technical and political information and feedback to and from citizens and government at all levels, defining ranges of possible decisions, the Governor, The Congress, the FHWA and FTA, the legislature and city mayors could take. "Alternative Program Packages" were carefully developed and evaluated, considering carefully everyone's interests. Because the process was *inclusive* and open, no one's agenda was excluded, nor were solutions based upon lack of information. Unknowns were treated in an informed manner leaving as many future options open to future decisionmakers as possible.

A clear statement emerged from the plan: that the people in Greater Boston wanted to reduce traffic congestion by using public transportation more and highways less to access the City. The plan, accordingly, described the systems to accomplish this objective in a thoughtful, detailed, and well documented way.

Doubts persist about whether the BTPR was predisposed against Interstate Highways. The Inner Belt plan was openly evaluated along with other transportation alternatives, and its supporters were listened to very carefully. What emerged was recognition of the problem inherent to Interstate Highways in urban areas:

In the country, building highways with four times the capacity of the traffic on surrounding streets is possible, but in cities, highways built to that same criteria, immediately fill to capacity. Urban Interstate highways are instantly too congested to serve for evacuation; it is unimaginable how they could work in an emergency. In non-emergencies, they increase congestion, because they allow more vehicles to use them than can access local streets. BTPR participants found so many more opportunities emerging from their mutual interaction, they put defense criteria in context, and went on to seek more rewarding solutions.

The BTPR recommended Massachusetts transfer some of the Interstate Highway funds apportioned to the Boston Region to transit instead of highway purposes, and that no additional highway capacity be built into the region's radial commuter road network. It recommended building a Third Harbor Tunnel to take through traffic out of the heart of downtown. This allowed north/southwest through traffic to connect directly with the Massachusetts Turnpike. It also recommended depressing a section of elevated highway built in the mid-1950's, which severs Boston's Business District from its historic waterfront, called the Central Artery. In the 1980s even before the depressing the Central Artery had been approved, anticipation of the Project inspired a major economic renewal of the buildings surrounding the Artery corridor.

The principal transportation benefit of depressing the Artery was a rail link, to be built as part of it, between the two railroad systems serving north and south of Boston. This filled in the only missing track in rail service along the Atlantic Coast from Florida to Maine, and allowed commuter trains to traverse the city instead of terminating at separate stations. It opened new regional markets for labor and business activity by increasing City accessibility via public transportation, and made the use of interconnecting bus, transit and commuter rail systems dramatically more attractive through reduced transfers.

While the rail link didn't guarantee people would leave their cars at home or in suburban stations, it provided an attractive and affordable alternative means of travel into and out of Boston, and helped people walk to destinations in a restored historic waterfront through an environment designed for pedestrians.

The rail link allowed highways serving Boston to be constrained, if the public wanted to reduce congestion, without sacrificing affordable accessibility to those who chose to enter or leave by rail.

The BTPR planning process and its resulting intermodal plan were so powerful, that its recommendations were pursued with confidence. The excitement which had been created in Boston soon brought national attention and special focus to implement the plan temporarily eclipsing attention to other areas across Massachusetts.

Because the federal government had not yet approved ISTEA, the Central Artery Project became an Interstate Highway improvement under FHWA rules in 1983. More will be said about the Interstate Program in a moment. Under these rules, the design grew to carry three times more traffic. The rail link was dropped, because it was perceived to be in competition, and the project doubled in cost. As people found themselves less clearly associated with it and concerned about values they felt were being dismissed, the project further began to accumulate a staggering list of additional costs to "mitigate deficiencies."

Last year, Massachusetts Governor William Weld formed a Task Force to determine whether the rail link *could* be returned to the Project. After three months, that Task Force found it could, and that rather than interfering with the Artery, it made it consistent with ISTEA and could possibly help its construction. Congress approved \$4 million to start the rail link's environmental impact statement, and the Massachusetts Legislative Transportation Committee approved \$60 million in state funds to match federal preliminary funding. A full Legislative approval is pending approval of funds to help people all across the state. A Rail Link Caucus for members of the Massachusetts Legislature attracted the participation of 183 of the state's 200 legislators last year, who recognized the rail link both as good politics and as good business.

There is strong business support for building the Central Artery Project and the Rail Link. Congestion constraints will be necessary to achieve mandated compliance with the national Clean Air Act Amendment. Constraining some of the traffic, built into it for defense reasons, may enable some of the Project's costs, disruption and contention to be reduced. This could update the Project to make it even more consistent with national transportation policy and the BTPR master plan. It could also speed its implementation.

DISILLUSION AND COLD WAR SPENDING POLICIES

That same summer of 1945, when you might have reached my father with Georgette's help at a friend's house in Vermont, America dropped the bomb on Hiroshima. It was as if I took a revolver from my briefcase, and fired it at the ceiling. The bomb instanntly captured world attention in a single day. The waves caused by this explosion are still being felt now, fifty-years later, and are unlikely to subside any time soon.

That August day in 1945 changed an age of almost delirious optimism into one of almost equal cynicism within the space of fifty years. The dreams of unrestrained power and wealth resulting from a new age of machines had turned from good to evil. The powerful conviction that man's inventiveness could lead to whole new paths of life and great societies was shattered. Moral judgment and authority, the very foundations of American Democracy, were sorely and severely challenged. 200,000 mostly innocent people died in five days, and 150,000 more were to die in the next five years.

The excitement of discovery, and the energy gleaned from new sophisticated machines had started a race for world supremacy among industrial nations at the turn of the century. By World War II, most of this energy was focused on war preparations to control who would oversee its power. People had been preparing for or waging war for 30 years. Everyone had sacrificed time, energy, and money in the spirit of the nation's best interests and national defense, and had helped build the tools to win it. Then, that August day showed these same tools could unwittingly annihilate all life on Planet Earth.

It stopped World War II. After the Russians announced their own bomb, our response at home was pure panic. We built bomb shelters, so some of us at least, would survive if a bomb landed on the United States. The "Doomsday Project" at the Pentagon, to sustain the country's leadership in the event of nuclear war, is only now being phased out.

The price of war had already taken its toll, the country was recovering from a severe depression, and money was scarce. Congress enacted a series of focused, single purpose, military-like programs to reinspire national reinvestment. These included massive federally subsidized and controlled programs in transportation, urban renewal, housing, banking, health and social security, everyone of which proved unsustainable.

Popular misconceptions about Cold War economic policies abound. Some of these programs might have been more sustainable had they focused upon longer-term objectives, but it was considered mandatory to regain government respect and quickly revive credibility, thus people's attention was riveted on short-term engagements. These inspired a wave of short-term profit taking, and nearly bankrupted the American economy.

Marketers, for example, made products specifically designed to wear out more quickly, on the theory that would persuade customers to repurchase. This idea quickly opened the doors to foreign competition. The oil industry created a cartel with automakers, steel producers, rubber, asphalt and concrete plants which regulated what could be sold and soon controlled highway construction. It was convinced this was how progress was made. It thought interconnected businesses were the wave of the future, which they might be if used less exclusively and less defensively. It mistakenly thought wealth came from keeping it from people who were not part of the cartel. The cartel thought our national defense highway system was helping our automobile industry, when in fact, it was keeping it from competing with German and Japanese manufacturers, who soon took over the industry.

Many people today believe conflict is inevitable and people can only work together in times of crisis. As a result, many people today are out-of work, profoundly skeptical, and the costs of doing business have skyrocketed. Some wonder if all new technologies are dangerous. The Cold War with Russia may be over, but the Cold War between people here is still raging furiously.

These circumstances made fertile ground for the environmental movement. Born in reaction to short-term thinking and the consequences of that August day, it spread like white blood cells to a spreading infection. As one might expect, it interfered with progress, and some of its soldiers still do. But it started to change our thinking to consider expediency differently, to look into long term consequences more fully, and to seek new ways of doing business.

Many people today don't understand why major public works should be stopped to preserve endangered species, while others are wondering if man isn't one of them. Neither crisis view is very useful in itself. But what the BTPR demonstrated was that both views have merit if both are pursued and refined together. As opposed to discarding views as too extreme to be important, the BTPR used opposing views to discover new solutions which sustained both action and long-term objectives more efficiently.

If we take a century-long overview of our progress this past century, it appears we may not have progressed quite as radically as everyone had expected and that most of the problems and conflicts which have confounded man before still persist. At the same time, our optimism and struggles to build new frontiers have driven us to discover amazing new ways to help confront these conflicts more knowledgeably, and we may be realizing for the first time that planning ahead might enable us to progress more fruitfully.

POST COLD WAR INTERMODALISM

Intermodalism is a new transportation term narrowly interpreted to mean improving the interrelationships between modes. But it is a concept which can and should be interpreted more broadly. Turning intermodalism from a challenge into an opportunity means allowing it to address not only travel modes, but the multiple social, economic, and environmental values which influence transportation choices and decisions. Many transportation research investments can be made narrowly, but will gain value and purpose if linked to other interests through cross-modal, cross-disciplinary thinking. These are considerations, which all levels of government and private industry must now address to achieve more sustainable economic systems, tools, and jobs.

There was an interesting address given at the New England Museum Association's Annual Meeting last year by W. Richard West, the director of the National Museum of the American Indian. What he said about his museum can be usefully said about the transportation industry. Therefore, with his permission, here is some of his speech transposed accordingly. In his speech, W. Richard West begins by quoting Robert McCormick Adams, the Secretary of the Smithsonian Institution, who wrote the following statement about the new museum:

As "This national museum (that) takes the permanence, the authenticity, the vitality and the self-determination of Native American voices as the fundamental reality it must represent, we move decisively from (an) older image of the museum as a temple with its superior, self-governing priesthood to a forum which is committed not to the promulgation of received wisdom, but to the encouragement of a multi-cultural dialogue".

A transposed statement about the transportation industry might read:

As America's transportation industry takes the permanence, the authenticity, the vitality and the self-determination of American voices as its fundamental reality, it must move decisively from an older image of the industry as a temple with its superior, self-governing priesthood to a forum which is committed not to the promulgation of received wisdom, but to the encouragement of a dialogue with all citizens.

No one will likely ever succeed in controlling solely for themselves or their group many of the multiple new inventions which continue to be made as we move into a new century. The notion that these are the dominion of a select aristocracy was shattered fifty years ago. We are now bound together, by that accident, into sustaining our existence by assuring that future inventions are not used to exclude or coerce for short-term gains, but to open more universally sustainable opportunities. The century just behind us has dealt a profoundly humbling message: the tools we invent must be used constructively and not to destroy. Outmoded systems must be replaced with constructive alternatives, not simply destroyed. The machines we have discovered are not ends in themselves, but simply tools which provide opportunities to envision progress differently. This hardly means we dare no longer act any more than it ever did before. On the contrary, the exciting work has just started.

Planning events such as the BTPR may help us reach detente in the Cold War we seem to be having with each other, and make it easier to accept change from Cold-War to new growth policies:

1. Design Sustainable Planning Systems

ISTEA calls for integrated statewide and Metropolitan Planning Organization plans.

If these plans are drawn considering the full range of social, economic and environmental values and all known externalities of each state or region, they can acquire the similar solid backing for their common wisdom the BTPR achieved. When they do, this will enable subsequent project EIS submittals to draw upon this information with confidence rather than to require repeating studies with each subsequent project application.

Consider EIS planning not as an impediment required by bureaucrats or as an invitation to disagree, but as a vital educational experience. Realize the ripples the bomb made are the harbingers of change. A statewide or MPO plan may make smaller ripples, but its decisions will influence what happens for better or for worse, for the next fifty to one hundred years.

This means making decisions which support long and short-term opportunities, and using all available resources to act as wisely as possible. This means not discarding information or rules, but thinking constructively beyond them. It means cross-disciplinary thinking; acting the way Georgette did, using personal knowledge to connect people to new ideas or new ways to look at old ones beyond the information now listed in most books.

2. Design Sustainable Transportation Systems and Tools.

Population characteristics are changing. Unlike what was fashionable during the Industrial Revolution, industrialized countries are having smaller families. We recently discovered we were overfishing George's Bank. The view that economic health is necessarily linked to increasing everything must change and the benefits of longer-term qualities in smaller quantities must begin to be appreciated.

Helping cities build systems so people can live healthy, safe urban lives depends upon both changing urban living habits, and building sustainable communities. Both objectives can create good business. Skyscrapers and suburban sprawl are more energy consumptive and less easily sustainable than more moderate densities. More sustainable densities vary from place to place and are less expensive to build and maintain. But above all, these densities can be built with human-scaled designs which make people proud of them and want to care for them.

W. Richard West talks more about museums, saying: "America's educational system desperately needs our assistance, and we represent remarkable bundles of human and material resources that contain substantial stores of information, knowledge, and potential educational impact. Let me be very blunt about the reverse side of this coin -- I am extremely doubtful that either the public, or, for that matter the private sectors, come the next century, will be agreeable to supporting these very expensive institutions unless the public perceives that they have a far more general and democratized educational presence and impact."

Many existing transportation systems of the past were not planned for the future. It is said Boston's streets were planned by a cow. New criteria and the tools to more accurately recognize the consequences of planning decisions keep being invented. However they need a context in which to be understood and evaluated constructively. This context might be envisioned as an ongoing educational system, in which everyone participates, out of which come experiments in progress, systematically helping discover how we can treat the Earth and ourselves more gently.

Consistent with this approach are transportation tools which help to accurately educate travelers about systems choices and tools which expand their choices: cars which don't pollute, ways of using existing resources, such as rail systems more effectively, ways to preserve older buildings and build new tree-lined streets which remind us that many of the best examples of sustainable accomplishment have been around a long time. These are places which, centuries later, sustain admiration and respect. They increase in value by inspiring pride and care. They are typically full of human wisdom, human scale, delight and creativity for everyone. The more we build of these, the easier it becomes to inspire more confidence in the future.

3. Design Systems which use people and machines to do what each do best

Enormous amounts of useful planning information exists, but lots of it is seldom used. Planning has not been popular; people assume the information gathered will be used against them. The predictions of surveillance in the book "1984" have already taken place. We have already experienced "Big Brother" surveilling us as cold, inhuman, statistics. Few people in western societies have escaped being recorded. No city, nor state in the world has not been mapped. The data is there to enable us to drive up any street in the world via computer graphic systems, but not yet to look peacefully into the faces of those who live there, to ask how they feel, how we could help them and what ideas they have to help us. At least for the moment, this can be done with better results, face to face.

Images can now be projected on a computer screen, for most localities, showing where the transportation systems, police and fire stations are, where all the traffic goes. and where the crimes and fires have taken place. That traffic and those crimes and fires can be related unbiasedly to age, income, race, sex, marriage, mortgages, social security, insurance, and health care, if we want it to. This data, *if we want it to*, can be used to help the people

living on those streets together with people in business and government, to make constructive, creative, useful plans and market new inventions.

The binary system of computers, while remarkable in its ability to manage extraordinary volumes of complex data, remains an impoverished fool next to man whose memory of sight, hearing, smell. touch, and feelings provide hugely more information. Creativity, comes from individual thought and observation made by people *alone* with their thoughts. derived from connections they are able to draw from individual experiences. Great ideas emerge from all levels of intellect, age, and education: most ideas go unheard. Ideas grow strength by people building upon someone's creativity, adding to it respect and value and adjusting it to help it grow. Computers can help. Our diversity is the major source of our creativity. It may be our best assurance too that creativity will always eventually be constructively used. Our diversity expands our common vision to initiate new understandings of common "realities."

Jane Jacobs, the renown observer of cities, notes that cities are, and have always been the breeding grounds of economic resurgence; the places where ideas are formed through the interactions of people talking face to face and inventing new ways of doing things. Cities behave this way because they are places where people from everywhere come to meet, where their ideas can compete and cross associate and generate new vision.

Services are needed to design and support transportation planning concepts. Clear and sustainable concepts need less support. More services are needed, the more there is disagreement. Extending this analogy, the more sustainable we make development, the more easily we can shift growth from services back to manufacturing, thereby reducing the costs of doing business and increasing wealth.

W. Richard West's speech has been unabashedly quoted to correlate what is happening in museums with what is happening in the transportation industry. Here is another of his comments:

"Finally, I remain convinced that if we can accomplish all the foregoing, museums can be transformed into the vital forums for the exchange of cultural ideas and information and of debate that the Secretary of the Smithsonian Institution, Bob Adams, so elegantly described in my opening presentation. At that point I believe that museums, as social institutions will have the potential for assuming a role that ascends to an entirely new plane, which seems so logical, but which they have not achieved in any systematic way to date. Specifically, they will become far more important and pivotal- far more integral—to the continuing evolution of American culture. More important, they become not only the venues for debate but, perhaps, genuinely proactive instruments of the cultural reconciliation that this country appears so desperately to need."

This paper has been focused upon finding ways to use people's words and connections the way Georgette used the telephone in 1945. Most businesses today are aggressively pursuing programs which use employee participation to expand business opportunities. Most top executives agree, without employees buying into them, their plans do not work. Most everyone going to Home Depot today expect to find good products or return them for cash. With unemployment, for example, in France reaching 15%, overseas governments must also find ways to employ more people more usefully. Planning more openly and constructively, sharing ideas, building upon their crossfertilization and respecting contributions more freely are not only effective ways to reduce the deficit by controlling costs, but also of reducing unemployment by untying the constraints to new invention without sacrificing quality, so they can grow like clipper ships spanning the globe.

W. Richard West concludes his speech by quoting his Deputy Director who said "And museums will become different in a way that will, in the future, seem logical and self evident. I predict we will not be able to recreate what all the fuss was all about."

"From the longer view," W. Richard West states, "however, I have confidence approaching the serene that her prediction will prove absolutely prescient. And it is that long view which the National Museum of the American Indian, by history and perhaps destiny, is constrained to take. For us it is not only an option - it is no less than a cultural imperative."

The Transportation Industry may not envision itself as a cultural institution, nor that its options for future action are as imperative. Nevertheless, it may find sharing some of the cross-disciplinary thinking of the National Museum of the American Indian and of the Boston Transportation Planning Review worth exploring.

Thank you very much for your kind attention.

ACKNOWLEDGEMENTS

The authors are indebted to W. Richard West whose speech about the National Museum of the American Indian has been quoted so frequently, and to the following authors' papers, whose words were food for thought:

Richard Barrett Environmentally Sustainable Urban Transport

The World Bank Defining a Global Policy

John B. Hopkins Discussion Paper:

Aspects of Sustainable Transportation

Unsigned Sustainable Transportation

Proposal for a Transportation Research Board Study

Arnold Howitt

The Challenges of Transportation and Clean Air Goals

Alan Altshuler

VNTSC Charting A New Course in Transportation

Transportation Strategic Planning Seminars January 1993

APPENDIX - ABOUT THE AUTHORS

Harry Mathews is an engineer and a director of the Manufacturin g and Transportation industry Division of Arthur D. Little, Inc.. He is an experienced manager of complex small and large-scale multi-disciplinary industrial engineering projects. He is a skilled practitioner of business and technology feedback processes, and author of a recent research paper entitled: "Technology and Automation to Achieve Collision Free Passenger Cars by the 21st Century." Peter Roudebush is an architect, regional planner and interdisciplinary management consultant. He is an experience manager of small and large scale construction projects. He was interdisciplinary project manager (for Skidmore, Owings and Merrill), with the Boston Transportation Planning Review for Boston's Central Artery Project at its conception in 1972, and later manager of infrastructural roads and utility process systems for a new city in Saudi Arabia for the U.S. Army Corps of Engineers. Recently, he served on a task force for Massachusetts Governor William Weld, which discovered how to build a rail link between North and South Station under the depressed Central Artery, decoupled from the Artery's construction. Joining the rail systems north and south of Boston through the rail link makes the Central Artery Project intermodal, the city dramatically more attractive and accessible via public transportation, and connects Maine and New Hampshire into a more economically efficient and competitive coastal Atlantic (rail) transportation system.

Guiding Principles of the Boston Transportation Planning Review

The attached outline summarizes the paper "Building Consent for Post Cold War Transportation Iniatives" and provides a list of the characteristics of the Boston Transportation Planning Review participatory process, which enabled it to acquire widespread public consent. Management practices being employed by multi-national corporations to encourage employee participation based upon open discussion, information, and clearly defined goals mirror these quidelines in the private sector. These quidelines help define emerging new management practices successfully influencing government and private institutional change from past Cold War dogma to peacetime government/business/ and citizen partnerships.

TRANSPORTATION DEMAND MANAGEMENT AND INTELLIGENT VEHICLE-HIGHWAY SYSTEMS: THE NEED FOR MUTUAL COOPERATION

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INTRODUCTION

When the concept of Intelligent Vehicle-Highway Systems (IVHS) was originally conceived in the late 1980's. its stated purpose was to enhance and improve the security, comfort and convenience of driving a vehicle. Rapidly growing traffic congestion was threatening the pleasure and convenience of travelling by car. When the industry group IVHS AMERICA formed in 1991, IVHS had only four functional areas, none of which was devoted to using technology to improve transit. In addition, one of the four areas - "Advanced Driver Information Systems" - was specifically dedicated to improving the experience of driving a passenger vehicle.' Only later was the area renamed "Advanced Traveler Information Systems" and expanded to include other forms of travel besides the single occupant vehicle (SOV).

IVHS technology itself does not present a barrier to its use in reducing travel demand. Since the addition of "Advanced Public Transit Systems" to the IVHS framework, the Federal Transit Administration (FTA) has funded several projects which use advanced technology to improve convenience and efficiency of transit. Most projects funded through the FTA program involve disseminating information about high-occupancy modes (e.g. transit, carpools) to travelers before they make their mode choice. Other high technology demand management techniques include: congestion pricing, real-time rideshare matching, high-occupancy vehicle (HOV) monitoring and enforcement, telecommuting and on-site air quality inspection systems for "pollution pricing."

In response to criticism of its focus on the automobile, the IVHS industry expanded the concept of IVHS to include using technology to enhance and encourage travel by high-occupancy modes. In 1993, IVHS AMERICA established an Energy and the Environment Committee and a task force on Travel Demand and Telecommuting. *The National Program Plan for IVHS*, published by U.S. Department of Transportation (USDOT) with substantial input from IVHS industry advocates, names "Travel Demand Management" as one of 27 essential user services.

While the IVHS industry has begun to consider the reduction of travel demand as a legitimate goal, knowledge and interest of IVHS among transportation demand management (TDM) professions remains slim. At a recent conference on TDM, sponsored by the Transportation Research Board, a Federal Highway Administration staff member bemoaned the fact that so little of cutting-edge TDM research involved incorporation of new technologies.³

SOURCES OF CONFLICT

TDM and IVHS strategies to achieve the same results of reduced traffic congestion sometimes run contrary to each other. TDM focuses on reducing demand or shifting demand away from peak periods. However, increasing the vehicle-canying capacity of roads to reduce congestion was originally one of the stated goals of IVHS.

Through conversations with TDM professionals, CUTR has discovered that there is marginal confidence among TDM professionals that IVHS can attribute its success to genuine public demand for this technology. Conversely, TDM professionals most often name business support, lobbying efforts and infatuation with technology as motivations for the development of an IVHS industry. These opinions are similar to the those of the critics of IVHS. An editorial published last May in the *Tampa Tribune* describes IVHS as "expensive and of doubtful value." Architectural critic Jane Holtz Kay characterizes IVHS as "a retread of highway madness." Carl Thor of the University of Kansas Transportation Research Center calls IVHS "a Band-Aid approach that does nothing to address the cause of the [traffic congestion] disease." Clifford Watson of the Brookings Institution calls IVHS "a technology that is doomed." Marcia Lowe of the WorldWatch Institute predicts that IVHS projects will "exacerbate the very problems they are trying to solve."

Criticisms aside, the IVHS industry is also worried about the possibility of "technology push" - selling high-tech products for which there is no market. Anticipated revenue for IVHS product sales should outpace public funding for IVHS infrastructure, according to IVHS AMERICA's *Strategic Plan fir IVHS in the United States.*" Private citizens are expected to begin paying for IVHS systems through consumer services. If the market for IVHS products is non-existent or over-estimated, the IVHS industry is, indeed, doomed.

Preliminary studies, however, show a willingness to pay for IVHS features among certain groups. TravTek, the year-long operational test of in-vehicle navigation system technology conducted among Avis rental car users in Orlando, surveyed participants on their willingness-to-pay for the IVHS technology they had just rented. TravTek participants indicated a willingness to pay around \$400 for a TravTek-type unit for their own cars. However, survey respondents were not representative of the general population. The average annual household income of TravTek users was in the \$60,000 to \$80,000 range."

Another possible source of tension between IVHS and TDM proponents is the heavy emphasis within the IVHS industry on defense reinvestment. Half of ail members of IVHS AMERICA are from the space and defense industries, according to Executive Director James Constantino. Constantino predicted "a major shift toward IVHS technologies by companies and laboratories coping with reduced defense spending." The 1992 Clinton Administration economic plan states that research into certain defense-related technology constitutes research into the emerging technologies of IVHS. 13

TRB CONFERENCE ON TDM RESEARCH NEEDS

At an invitation-only symposium sponsored by the Transportation Research Board on the future research needs of TDM, the final session was designed to evaluate the importance of the research areas identified during the conference. Only 6 attendees indicated that "technological development" best represented their interest in TDM, and half of those were from the federal government. After consolidating some of the strategies, a total of 42 research areas were prioritized by 73 attendees. Prioritization differed based on the participant's employer. Only the private sector (private businesses and consultants) ranked one of the two technology strategies "expand the effectiveness of TDM by assessing available and potential technologies and market-based strategies" on their top ten strategies for TDM. Only TDM professionals employed at universities ranked the other technology strategy "conduct research in outreach on the application of IVHS to facilitate TDM program development" in the top ten. However, participants from government agencies and TDM operating programs did not include either technology strategy in their top ten list of issues. Clearly, TDM professionals remain skeptical about technology in general and IVHS in particular.

SIGNS OF DETENTE

IVHS proponents have taken several positive steps in bringing advocates of TDM and IVHS together for constructive dialogue. Among such positive steps are IVHS AMERICA's formation of the Energy & Environment Committee and TDM & Teiecommuting Task Force, and the USDOT's inclusion of "Travel Demand Management" as one of 27 essential IVHS user services.

In September 1993, the USDOT issued a Request for Participation (RFP) for operational tests of IVHS technologies in five key areas, one of which concerned TDM and pollution pricing. The purpose of the tests was to evaluate the ability of new technologies to conduct emissions testing of vehicles in motion. In April 1994, three proposals were selected. Under the operational test program, infra-red and LIDAR (a light-based sensor which detects distances of objects, similar to RADAR) sensors will be used to spot-check automobile emissions in Minnesota, Colorado and Idaho."

IVHS proponents have also stepped up their outreach activities to the general public, in addition to TDM professionals. In April and May 1994, IVHS AMERICA and the USDOT will host IO regional forums on the progress to date of the national IVHS system architecture design. The purpose of the regional forums, according to an IVHS AMERICA/USDOT brochure, is for the IVHS system architecture design teams to gain better understanding of the needs of various IVHS stakeholder groups. Environmental advocates, local transportation officials and environmentalists are among the many groups invited.

However, IVHS proponents should make the extra effort to reach out to TDM professionals on what IVHS is and how IVHS technologies can be used in their TDM operations. Though healthy skepticism exists in the TDM community about the potential of IVHS to address transportation problems, portions of the TDM community recognize the need for cooperation and integration.

This skepticism could be based on the TDM community's own experiences with influencing travel behavior over the past 25 years. During this period, the TDM community shifted from a product orientation to a customer-based orientation. Ridesharing programs with computerized "one size fits ail" ridematching systems, which did not differentiate among commuters have given way to ridematching systems which offer guaranteed ride home programs, vans with different features and address-based ridematching based on commuter preferences.

The identification of TDM as one of many IVHS stakeholder groups should send the message that IVHS has made the same transition. IVHS' customer-based orientation should focus on what travelers want and need.

LESSONS IVHS CAN LEARN FROM TDM

The IVHS community can learn from the mistakes TDM proponents made when first pursuing a product-oriented marketing approach. To embrace a customer-driven marketing approach, IVHS proponents should adopt the following approaches:

Do not see IVHS products as inherently desirable. IVHS proponents must start with the assumption that customers will not share their enthusiasm about IVHS products and services. This skepticism will force IVHS proponents to clearly explain benefits of the products to potential customers.

Dismiss the notion of customer ignorance. IVHS proponents should not attribute lack of interest in IVHS products customer's lack of understanding of the technology. If customers do understand the technology but remain uninterested, IVHS proponents have not found the right incentive.

Base strategic decisions on market research. The key to any successful business endeavor is market research. The principal role for research is merely to confirm beliefs. Yet, as most private sector marketers will attest, research results can challenge some managers' most fundamental assumptions about their customers.

Look to the TDM community for information on the commuter market. From marketing rideshare and other programs, the TDM community has gatheringconsiderable knowledge about the traveler behavior among different groups. Asian-Americans in Southern California are likely to live in racially homogeneous neighborhoods, an incentive to neighborhood-based carpooling. Affluent Hispanic-Americans and African-Americans are likely to view use of transit as a negative status symbol. Working parents, particularly women, are likely to combine their work commutes with other trips, i.e. dropping children off at daycare and grocery shopping. Knowing these distinctions can help IVHS proponents in designing marketing strategies for the most appropriate groups.

The most efficient way to reach the largest number of people interested in TDM is through the Association of Commuter Transportation (ACT), a professional organization of TDM professionals with over 1600 members. ACT publishes a bi-monthly newsletter *TDM Review* and hosts an annual meeting. The 1994 meeting will be September 1 8-21 in Miami, Florida. According to the Conference Program Chair, papers on dynamic ridematching are the only IVHS-related presentations submitted in response to the most recent call for papers."

The TDM community is skeptical about the ability of IVHS technologies to enhance their operations... skeptical, but willing to learn. Inviting TDM proponents to general IVHS outreach activities, making presentations on IVHS at presentations TDM conferences, including a module on IVHS in TDM professional education courses are just a few of the ways that detente can be achieved between these two seemingly divergent interests.

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IVHS AND ENVIRONMENTAL IMPACTS: IMPLICATIONS OF THE OPERATIONAL TESTS

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ABSTRACT

In recent years, public and private sponsors of Intelligent Vehicle-Highway Systems (IVHS) have recognized the need to assess the impacts of IVHS user services on air quality and energy use. This interest has been reinforced by the mandates of the Clean Air Act Amendments of 1990, the Intermodal Surface Transportation and Efficiency Act of 1991, as well as the desire to strengthen benefit-cost and air quality analyses.

The IVHS operational tests play a key role in the transition between research and development of new technologies and wide-scale deployment of IVHS user services. To date, the evaluation plans for most of the field tests have focused on important concerns of technical feasibility and user response. However, there remains significant, untapped potential for leveraging these tests to evaluate environmental impacts. In particular, empirical data gathered from field tests would greatly complement the use of models to assess the air quality and energy implications of wide-scale deployment.

Presently, the Volpe National Transportation Systems Center is investigating the evaluation goals and methods of the major domestic and international operational tests to gauge the state-of-the-practice for appraising environmental impacts. To date, the Volpe Center has identified approximately forty field tests with environmental evaluation objectives. Nearly all of these tests have employed or will use dissimilar methods to address the complex interactions between travel behavior, traffic operations, and the many confounding exogenous variables that govern vehicular emissions and fuel consumption. As a step toward creating an archetype for federal operational tests in the U.S., the Volpe Center is developing a guidebook that will recommend best practices for assessing energy and emissions impacts of IVHS user services.

INTRODUCTION

An essential objective of the Department of Transportation's Intelligent Vehicle-Highway Systems (IVHS) program is to identify, evaluate, and measure the private and societal impacts of IVHS user services. The operational tests are important means for accomplishing this end. Additionally, the Clean Air Act Amendments of 1990 (CAAA) compel better understanding and assessment of IVHS' environmental implications.

National governments in the United States, Europe, Japan, and Australia have sponsored over four hundred IVHS field tests, which are in various stages of development.' In the United States, the Department of Transportation (DOT) has supported seventy-six tests in partnership with various organizations, including State and local governments, private companies, and academia.²

The Purpose of IVHS Operational Tests

Operational tests are implementations of IVHS user services in "real-world" field environments. As stated in the DOT's *IVHS Strategic Plan: Report to Congress*, the criteria for selecting operational tests manifest the dual needs for demonstrating the technical feasibility of new technologies and services, and evaluating their public and private impacts.³ The criteria include:

"[O]verall contribution to the IVHS program knowledge base, the uniqueness of the proposed test...the degree of risk associated with the technologies involved, the suitability of the proposed site to support overall IVHS program test objectives, and ability of the existing infrastructure to support the test program...A major Federal responsibility in all operational tests is to ensure that impacts such as safety, mobility enhancements, and congestion relief are thoroughly evaluated."⁴

In the United States, the Intermodal Surface Transportation and Efficiency Act of 1991 (ISTEA) provides the regulatory support for the national IVHS operational test program. Although the DOT funded several major operational tests before its passage, ISTEA outlines the conceptual approach and procedures for their implementation.'

The DOT currently has authority to allocate approximately \$15 million per year to support IVHS operational tests, with a potential increase to \$30 million if Congress approves President Clinton's 1995 budget. In addition, ISTEA mandates field testing in four corridors located in severe ozone nonattainment areas. These test beds, designated as "priority corridors," include the Northeast Corridor (stretching along I-95 from Washington, D.C. to Connecticut), the Midwest Corridor (centered around Chicago and extending through Milwaukee), the Houston Texas metropolitan area, and the Southern California Area Corridor (centered along I-5 from Los Angeles to San Diego).' For these priority corridors, ISTEA provides \$86 million per year from fiscal year 1993 through 1997 to establish an "IVHS infrastructure that will support continued deployment of IVHS technologies and services."*

More specifically, ISTEA requires that the operational tests have written evaluation plans and charges the Secretary of Transportation with establishing guidelines and requirements.' To support these requirements, the Federal Highway Administration (FHWA) developed generic IVHS operational test evaluation guidelines that prescribe the necessary components and contents of formal evaluation procedures. These guidelines provide a standardized structure for operational test evaluation plans, but stop short of delineating precise methodologies for measuring impacts."

Most recently, FHWA charged the Volpe Center with producing two guidebooks that will recommend best practices for conducting market research and for evaluating the emissions and fuel use impacts of IVHS in field test settings. FHWA is also in the process of obtaining additional staffing and expertise to "assist in the development of evaluation plans and provide technical assistance in monitoring the evaluation for IVHS operational tests nationwide." These efforts underscore the DOT's commitment to leverage the operational tests for improved understanding of IVHS' implications. The DOT affirms its intentions in its report to Congress:

"The primary source for direct measurement of the impacts and benefits of IVHS user services will be the evaluations of operational tests. Evaluation requirements will affect the design of these projects, as will the need to develop and incorporate data collection systems for capture of necessary information regarding travel behavior and other impacts such as energy and environmental effects.""

The operational tests, therefore, are not only test beds for resolving the technical feasibility of IVHS user services, but important proving grounds for appraising their societal and private implications.

The Impetus for Environmental Evaluation

In the United States, a number of federal regulations, including the CAAA, ISTEA, and the National Energy Policy Act of 199 | (NEPA) stress the transportation sector's obligations to support environmental and energy security objectives.

In particular, the CAAA established national ambient air quality standards for ozone, carbon monoxide, nitrogen dioxide, particulate matter, lead, and sulfur oxides to safeguard human health and welfare. The U.S. Environmental Protection Agency (EPA) classifies cities and regions as "nonattainment areas" when the measured concentrations of these pollutants exceed their designated standards. To ensure that air quality objectives are met, the CAAA requires nonattainment areas to develop State Implementation Plans (SIPs), which inventory emission sources and identify control measures to ensure progressive attainment of the air quality standards.

Motor vehicles are significant contributors to the production of ozone (by emitting hydrocarbons (HC) and nitrogen oxides (NO,,, which photochemically react to produce ozone), carbon monoxide (CO), and particulate matter. Although the CAAA mandates cleaner fuels and cleaner cars (through improved inspection and maintenance and more stringent emissions controls), these steps alone will not sufficiently alleviate the transportation sector's obligation to reduce its emissions. As a result, nonattainment areas will turn to transportation control measures, including IVHS user services, to meet air quality objectives. Although the CAAA emphasizes transportation control measures as proactive solutions, it also insists that transportation plans conform to the intent and objectives of the SIPS and not aggravate the frequency and severity of air quality violations. As a result, transportation planners must prove that their proposed projects will, at a minimum, "do no harm." For some environmental advocates, even the implementation of environmentally neutral projects may not be satisfactory.

Purpose and Scope

Given the DOT's objectives and the regulatory context, this paper examines the implications of the operational tests for assessing the environmental impacts of IVHS user services. The paper focuses on nationally sponsored field tests, but acknowledges, when possible, the efforts of local governments and the private sector. The contents include a discussion of the following:

- The fundamental elements and relationships that must be considered by operational tests in order to evaluate the emissions and fuel consumption impacts of IVHS user services.
- The scope of IVHS field tests with environmental evaluation objectives in the United States, Europe, Japan, and Australia.
- The state-of-the-practice for appraising the environmental impacts of IVHS user services in field settings, including the use of experimental design, data collection, and analytical methods.
- Results on IVHS' environmental impacts available from completed field tests.
- The Volpe Center's efforts to develop a guidebook for conducting environmental evaluations within IVHS operational tests.

CONSIDERATIONS FOR ENVIRONMENTAL EVALUATIONS

The evaluation of emissions and energy impacts of IVHS technologies and services presents special challenges for operational tests. Not only are the processes that govern vehicular emissions and fuel consumption varied and complex, but IVHS user services can have multiple direct and indirect impacts on many parameters that affect these processes. In particular, operational tests cannot assess environmental impacts without first considering IVHS' impacts on travel behavior and traffic conditions in the context of site-specific conditions (fleet mix, temperature, etc.).

Emissions are a function of many factors that will likely not be affected by IVHS user services, including temperature, altitude, fuel type, road geometry, as well as vehicle class, maintenance and load, Air quality impacts are even more difficult to assess since they can result from reactions of pollutants from potentially varied and multiple sources, and are influenced by topography and meteorological conditions. Fuel economy is also a function of many parameters that will likely not be impacted by IVHS, including vehicle class and road geometry.

IVHS user services, however, can influence emissions and fuel consumption impacts by altering baseline levels of transportation supply and demand. In particular, emissions and fuel consumption are sensitive to changes in traffic flow pattern (e.g., the pattern and magnitude of cruise, acceleration, deceleration, and idle), the number of vehicle trips, vehicle miles traveled (VMT), and mode shifts (e.g., from cars to buses).

Traffic management user services, such as dynamic signal coordination, ramp metering and incident management, can directly alter traffic flow patterns. Traveler information user services, although they do not change

transportation operations directly, increase travelers' knowledge of transportation options. In response to supply changes and new knowledge, individuals will make decisions regarding travel activity (e.g., trip-making, departure time, route, mode). The aggregate effect of individual responses could affect system-level supply or demand characteristics. Most of the operational tests as currently scaled, however, will likely not be large enough to measurably affect aggregate traffic operations or travel demand.

For environmental impact analysis, it is particularly important to distinguish the prospective impacts of pretrip planning and en-route information. En-route information, provided by changeable message signs and on-board route guidance systems, can potentially affect route choice, which could indirectly impact VMT and travel speeds for individual motorists. Pre-trip information can potentially affect the full range of travel activity choices, most importantly trip-making and mode preference. In addition, the U.S. DOT and others are developing and supporting new user services that inform motorists of non-transportation related characteristics, such as their vehicles' emissions, in the hopes of more directly achieving environmental objectives. ¹³

Because environmental impact assessment can follow only after IVHS' direct and indirect impacts on travel activity and traffic operations are appropriately appraised, this paper gauges the state-of-the-practice by addressing whether and how operational tests answer the following questions:

- How will the demonstrated IVHS user service(s) affect traveler behavior, particularly trip-making, departure time, mode choice, route choice, or other decisions that could impact environmental measures?
- What changes will the IVHS user service(s) produce on traffic operations, particularly VMT, speeds, and driving characteristics?
- How will changes in travel activity and traffic operations directly and indirectly impact emissions and fuel consumption, in the context of site-specific conditions?

To evaluate IVHS environmental impacts, operational tests must design discrete, but integrated, strategies that can measure changes in travel behavior, traffic operations, emissions, and fuel consumption. More specifically, the operational tests must develop resourceful experimental designs that delineate appropriate data collection and analytical techniques. ¹⁴

THE SCOPE OF FIELD TESTS WITH ENVIRONMENTAL OBJECTIVES

To date, we have identified approximately forty field tests in the United States, Europe, Japan, and Australia, with environmental evaluation objectives. Tables 1 through 9 summarize the demonstrated IVHS user services, status, major goals, experimental designs, data collection, and analytical methods for each of these field tests. About a dozen of these tests have completed their analyses and published results. Because our investigations are still in progress, this paper's findings are preliminary and do not reflect a definitive accounting of tests planning to assess environmental impacts.

The Volpe Center obtained its information from draft and final evaluation plans, documents prepared by and for DOT and IVHS AMERICA, as well as the general body of IVHS literature. Whenever possible, the Volpe Center supplemented the written literature with telephone and in-person interviews with key participants of the operational tests.

The United States

We identified fifteen field tests in the United States with plans to evaluate the emissions and/or fuel consumption impacts of their IVHS user services. All but two of these tests are federally supported. The evaluation goals and objectives are summarized in Tables 1 through 4.

In the United States, operational tests develop autonomous evaluation plans, which address particular site-specific system designs and particular interests of the test partners.

For the most part, the operational tests demonstrate IVHS user services, where environmental concerns are secondary to other objectives, such as congestion reduction. The range of IVHS user services include dynamic signal coordination, ramp metering, pre-trip planning services for transit users and private motorists, and en-route information via dynamic route guidance and changeable message signs.

The DOT and the IVHS community have been especially cognizant of the need to demonstrate IVHS user services that can be proactively deployed to satisfy air quality objectives. In 1994, the DOT identified three new operational tests, which will implement travel demand and traffic management strategies in response to real-time pollution monitoring." In addition, two Southern California counties plan to demonstrate a real-time data collection system designed to facilitate transportation and air quality planning. Although these field tests may show that certain technologies are environmentally beneficial, they will not obviate the need to evaluate the environmental impacts of more conventional traffic management, traveler information, and public transit user services, which metropolitan areas may wish to adopt to mitigate congestion or influence travel demand.

The range of field tests with environmental objectives is summarized below by IVHS user service:

Traffic Management Systems

The Volpe Center identified three tests, ATSAC, FAST-TRAC and Smart Corridor, ¹⁶ which demonstrate dynamic signal coordination and its impacts on arterial traffic flow. Smart Corridor is also field testing dynamic ramp metering. ATSAC, a non-federally funded project that concluded in 1987, has the only published evaluation of the environmental impacts of dynamic signal coordination in the United States." The study indicated that the ATSAC system reduced vehicular emissions and fuel consumption in the control area.

Traveler Information Systems

The Volpe Center identified seven operational tests, which demonstrate the feasibility of traveler information systems. Three of these tests, ADVANCE, TravTek, and FAST-TRAC, will provide en-route information to motorists equipped with dynamic route guidance systems while two other tests, Guidestar Genesis and SmarTraveler, provide pre-trip and en-route information through personal communication devices and telephone, respectively. Smart Corridor also considers the diversion impacts of changeable message signs. Of these tests, only SmarTraveler has completed an environmental evaluation, which indicated favorable air quality impacts. TravTek's evaluation will be completed within the next few months.

Environmental Management Systems

As mentioned previously, the U.S. DOT identified three projects that will demonstrate IVHS user services with primary environmental objectives. In addition, Southern California counties plan to implement a real-time data collection system to support transportation and air quality planning.

The first test ("Evaluating Environmental Impacts of IVHS using LIDAR") will control traffic around a sports arena in Blaine, Minnesota in response to area-wide particulate emissions monitoring using Light Detection and Ranging (LIDAR) technology and infrared remote sensing of roadside emissions. Air quality data will be correlated to traffic volume data, superimposed over a Geographic Information System (GIS) base map of the project area, and provided to the Minnesota DOT's portable traffic management system (PTMS), which will optimize traffic flow to minimize local pollution.

The objectives of the second test ("IVHS for Voluntary Emissions Reductions") are to identify superemitting vehicles through infrared remote sensing and inform drivers of their vehicles' emissions output via a variable message sign. The field test may also include a highway advisory radio message at the site, a telephone information hotline, and educational materials at local service stations that would provide additional information on the environmental benefits of keeping vehicles well-tuned. The third federal test ("Travel Demand Management Emissions Detection") also uses infrared remote sensing to determine the relative contributions of in-county and out-of-county vehicles to mobile source emissions within Ada County, Idaho. The information will be provided to motorists, recommending voluntary or potentially subsidized vehicle repair for high-emitters.

PLANMODE (Planning and Modeling Data Environment) is a non-federally funded project that will collect real-time data from three components: AutoProbe, which uses GPS-equipped vehicles to collect trip-related data (e.g., speeds, VMT), AutoCensus, which collects traffic census data through a network of call boxes, and DriveCLEAN, which consists of call boxes and mobile source emissions sensors that measure point source air quality. The PLANMODE system will eventually link the collected data to a GIS system. The information would be provided to transportation and air quality planners. '*

Public Transit Systems

The general evaluation guidelines for advanced public transportation systems identify air quality and energy measures of effectiveness, including perceptions of riders regarding transit use and air quality as well as impacts on CO, NO,, and fuel use." To date, we identified one public transit system user service, Guidestar Travlink, which may qualitatively estimate emissions and fuel consumption impacts as a function of changes in trips and mode. Travlink will provide real-time transit and traffic information through videotex terminals, electronic signs, smart kiosks, and transit station displays.

Commercial Vehicle Operations

The Volpe Center identified one commercial vehicle operational test, ADVANTAGE I-7.5, which plans to evaluate the emissions and fuel consumption impacts of weigh-in-motion technologies. ADVANTAGE I-75 expects to improve the efficiency of commercial vehicle operations by allowing 4,500 transponder-equipped trucks to travel at freeway speeds with minimal stopping at roughly 30 weigh and inspections stations. The test is considering measuring emissions and fuel consumption through empirical methods that have not yet been identified.

In addition, Latshaw and Nutly have documented eight case studies of the effectiveness of scheduling and route optimization of commercial vehicles in the private sector. The study indicates that, in general, scheduling and route optimization systems reduced trips, VMT, and stops as well as vehicular emissions."

Europe

The European focus has been on the development and evaluation of diverse IVHS technologies and services." The two largest IVHS European programs are PROMETHEUS (Program for European Traffic with Highest Efficiency and Unprecedented Safety) and DRIVE (Dedicated Road Infrastructure for Vehicle Safety in Europe). Additional European IVHS programs include POLIS and CORRIDOR, which support urban field tests, and CARMINAT, DEMETER, ERTIS, and EUROPOLIS.²²

PROMETHEUS was initiated in 1987 by a consortium of European automobile manufacturers and later supported by national governments and research agencies. The program, which will conclude in 1994, originally allocated \$770 million for 1986 through 1993.²³ PROMETHEUS' goals are to advance real-time information and vehicle control systems that can improve traffic flow and safety.

In parallel, the DRIVE program, which is coordinated by the European Community, focuses on developing a pan-European infrastructure. DRIVE's goal are to improve transportation efficiency and safety by implementing an Integrated Road Transport Environment (IRTE), which will provide real-time information on traffic conditions. The original 71 DRIVE projects were conducted from 1980 to late 1991. A second series of nearly 70 projects, DRIVE II, focus on field operational tests, which address both technical feasibility and benefit evaluation. From 1988 through 1994, the combined DRIVE I and DRIVE II budget totaled roughly \$460 million, half of this provided by the public sector. ²⁴

Europe has been particularly aggressive in developing field test programs to assess environmental impacts. These programs not only evaluate impacts of conventional IVHS user services, but seek to demonstrate unique systems that can be proactively employed to meet environmental objectives. The Volpe Center identified sixteen field tests with environmental evaluation objectives, which are summarized in Tables 5 through 7.

PREDICT, funded by DRIVE I, was one of the first European field tests with an environmental focus. The other field tests are supported by four programs, QUARTET, SCOPE, THERMIE, and KITE. These programs provide resources to ensure that consistent, comprehensive, and credible methods are used to assess environmental impacts of IVHS technologies and services.

PREDICT

PREDICT (Pollution Reduction by Information and Control Techniques) assessed the emissions and air quality impacts of environmental traffic management systems, including environmental optimization of traffic signals, pollution-sensitive rerouting and environmental area licensing. The project, which was based in Athens, Greece, developed a modeling suite to predict the pollution impacts of various traffic management and control strategies. In addition, PREDICT evaluated ambient air quality monitoring systems and developed plans for several European cities.

OUARTET

QUARTET (Quadrilateral Advanced Research on Telematics for Environment and Transport) supports field tests in four cities, who each take the lead in implementing one or two specific IVHS elements, called modules. The participating cities and their modules are Athens, Greece (environmental module), Birmingham, U.K. (public transportation systems module), Stuttgart, Germany (route guidance and the emergency call systems modules), and Torino, Italy (IVHS architecture and the management and coordination modules). Each of the cities considers integration of its IVHS module with other modules and collaborate on tasks of common interest.

APOLLON, located in Athens, is QUARTET's environmental module and is a follow-up to PREDICT. The field test evaluates the effectiveness of deploying real-time traffic control strategies in response to expected high pollution episodes. APOLLON, which is expected to begin testing in mid- 1994, consists of environmental monitoring, continuous monitoring of traffic flows, traffic rerouting, short-term meteorological forecasts, restrictions on high emitting vehicles, and air quality models to estimate expected traffic pollution levels.²⁷

SCOPE

SCOPE (Southampton, Cologne, and PiraEus), which is funded by DRIVE II, encompasses three projects: ROMANSE (Southampton, England), VICTORIA (Cologne, Germany), and PORTS (Piraeus, Greece).** Two of these projects, ROMANSE and VICTORIA, plan to evaluate both vehicular emissions and air quality impacts. ROMANSE consists of variable message signs, dynamic traffic guidance, high occupancy vehicle priority lanes, environmental traffic control, and various public transportation systems. The project emphasizes the use of a multimodal information system, which will collect, evaluate, and disseminate real-time and forecast data on traffic conditions and transit schedules. VICTORIA also integrates traveler information and traffic management user services.

THERMIE

The goal of THERMIE, which began in 1990, is to promote improved energy efficiency using existing and new technologies." THERMIE has allocated nearly \$20 million to support transportation projects, including two IVHS programs, JUPITER (Joint Urban Project In Transport Energy Reduction) and ENTRANCE (ENergy savings in TRANsport through innovation in the Cities of Europe).

JUPITER is a three-year project designed to field test public transportation technologies and services that "save energy and improve the urban environment." The field tests will demonstrate passenger information services,

public vehicle priority lanes, traffic restrictions, and new public transit vehicles, some of which will use alternative fuels. Tests are planned for Aalborg, Denmark; Bilbao, Spain; Florence, Italy; Ghent, Belgium; Liverpool, U.K. and Patras, Greece.

ENTRANCE, a three-year project with a budget of nearly \$12 million, promotes public transportation systems as well as some dynamic route guidance in seven "core" cities: Southampton and Portsmouth, U.K.; Cologne, Germany; Piraeus, Greece; Evora, Portugal; Rotterdam, the Netherlands; and Santiago, Spain. In addition, ENTRANCE shares knowledge gained from these field tests with three 'dissemination' cities: Caen, France; Cork, Ireland; and Dresden, Germany. These cities develop plans for deploying the technologies tested in the seven core cities. One of the primary goals of the ENTRANCE program is to shift single occupancy vehicle travel to public transportation systems by promoting park-and-ride, passenger information, and overall public transit efficiency. In addition, the program is evaluating the use of alternative fuels, such as compressed natural gas (CNG), for public transit buses.

KITE

The members of QUARTET and SCOPE received funding from DRIVE II to create KITE (Kernel project on Impacts of Transport telematics on the Environment), which aims to develop a standard "modeling suite" for assessing the environmental impacts of IVHS user services. KITE, which is led by Cologne, Germany, consists of twenty partners and has a budget of a little over \$550 thousand. XITE will use its modeling standard to perform a number of case studies on the environmental impacts of IVHS user services in several European cities, including the three SCOPE cities and four QUARTET cities. KITE convened an expert panel in late 1993 and is in the process of assessing current models and analytical techniques.

Japan

Japan's IVHS program has emphasized the development and deployment of advanced traffic management systems for arterial streets and in-vehicle navigation systems.³⁴

Japan had 74 advanced traffic management centers and 87 sub-centers in operation by 1988-1990. During this same period, Nissan and Mazda marketed automobiles equipped with navigation systems. The Tokyo Metropolitan Police Department also established a pilot Advanced Traffic Information Supply Service (ATISS). 35

The Volpe Center identified two field tests of dynamic signal coordination, both with published results on emissions and fuel consumption impacts: the Comprehensive Automobile Traffic Control System, which was completed in Tokyo in 1979, 36 and a field evaluation conducted by the National Police Agency in 1993. 37 Both field tests, whose evaluation plans are summarized in Table 8, indicated positive environmental benefits of dynamic traffic control over fixed-time signalization.

Australia

Australia developed the adaptive traffic control system, SCATS (Sydney Coordinated Adaptive Traffic System), which is installed in more than thirty cities world-wide. During the 1980s several Australian organizations evaluated SCATS relative to no traffic control and simple fixed-time signal control systems in Sydney and Melbourne Australia; Conventry, U.K.; and Glasgow, Scotland. Table 9 outlines the evaluation proposals and results. The studies indicate that SCATS reduced travel times, number of stops, and total fuel consumption relative to no traffic control and conventional fixed-time control systems.³⁸

STATE-OF-THE-PRACTICE FOR ENVIRONMENTAL EVALUATION

This section assesses the state-of-the-practice for conducting environmental evaluations in operational tests. Because our investigations are still ongoing, the content is more descriptive than evaluative. In addition, we do not attempt to describe the evaluation strategies of every test shown in the attached tables, but instead present a cross-section of methods to show the breadth and diversity of approaches.

In general, we found that the operational tests are employing diverse techniques to evaluate travel behavior, traffic operations, emissions, and fuel consumption. For the most part, these strategies weigh heavily toward assessment of user response and travel behavior. In particular, several of the U.S. operational tests investigated so far have not yet identified the analytical methods to calculate emissions and fuel consumption impacts.

Most of the tests favor models over strictly empirical methods to assess emissions and fuel use impacts, particularly since the relatively small scale of most of the tests prohibit measurement of system-wide impacts. In addition, changes in emissions and air quality resulting from the implementation of IVHS user services will be difficult to measure directly because of confounding influences of stationary sources and fleet variability. State-of-the-art models, however, are not sufficiently developed to estimate the environmental impacts of traffic and travel demand projects. In addition, conventional travel demand and traffic simulation models cannot adequately estimate real-time impacts on traffic operations and consider differences in travelers' knowledge of transportation operations and travel choices.

Because both empirical methods and models have inherent biases, a few operational tests plan to use multiple methods to obtain ranges of results. For example, INFORM used three different methods to collect data on traffic operations for its statistical evaluation of ramp metering and signal coordination 40,41 while TravTek designed ten different evaluation methods for assessing the effectiveness of its dynamic route guidance vehicles. 42

The analytical methods for estimating IVHS impacts on travel behavior, traffic operations, emissions, and fuel consumption are discussed below:

Travel Behavior

For the most part, operational tests demonstrating traffic control strategies, such as dynamic signalization and ramp metering, do not address travel behavior while the evaluation plans of traveler information user services emphasize travel behavior impacts.

With one exception, the operational tests investigated so far do not plan to use models to evaluate travel activity impacts, but instead will rely on a variety of surveying techniques. In addition, based on the written evaluation plans, the tests do not appear to consider potential latent demand resulting from improved mobility. One of the exceptions, TravTek, plans to perform parametric analyses by varying market penetration and travel demand variables provided to a traffic simulation model, INTEGRATION.

Empirical Analysis

For the most part, operational tests will use surveys, interviews, panels, and other empirical methods to obtain a wide range of information on travel behavior, including trip origin-destination, departure times, routes taken, and mode preferences. However, for the most part, the tests plan to structure these methods to assess user response and not explicitly to estimate emissions and fuel consumption impacts. For example, SmarTraveler, in its assessment of response to real-time traffic information, asked users if they changed route, mode, or departure time as a block of choices rather than discrete choices. The survey also qualitatively assessed the amplitude of travel behavior changes (e.g., "frequently", "occasionally", "never"). As a result, SmartRoute System's later environmental evaluation inferred specific travel activity changes from the survey's more aggregate information, which introduced additional uncertainty in the results.

Some tests, most notably FAST-TRAC, SmarTraveler and TravTek, plan to develop baseline measures of origin-destination travel demand. FAST-TRAC is pursuing baseline data through the Southeastern Michigan Counci: of Governments, the local metropolitan planning organization, while SmartRoute Systems obtained baseline travel demand data from Boston's Central Transportation Planning staff in order to evaluate emissions impacts. TravTek developed origin-destination demand using a model, QUEENSOD, which infers origin-destination from actual traffic flow counts.

Models

With the exception of the ROMANSE project in Southampton, England, the use of regional planning (travel demand) models to assess travel activity impacts is notably absent. Travel demand models predict travel activity as a function of socioeconomic characteristics, land use patterns, and the transportation infrastructure. The models typically use a four step process of trip generation, trip distribution, mode split, and route assignment to characterize travel activity. Two projects, PREDICT and APOLLON, use a route assignment model, PDIAL, to evaluate environmental rerouting strategies.

ROMANSE, a demonstration of public transit systems, will use a travel demand model, EMME2, which is described as a "strategic model, capable of representing modes such as bus and rail, as well as the privatecar." ROMANSE uses EMME2 to quantify the impacts of park-and-ride and priority bus measures on person and traffic movements. The evaluators will calibrate the model using stated preference surveys and other observed data. The Transportation Research Group at the University of Southampton, a test partner, is also developing a car park occupancy prediction model to evaluate parking strategies.

Traffic Operations

Nearly all of the operational tests plan to collect field data and conduct some combination of empirical analysis and modeling to ascertain impacts on traffic operations.

Empirical Analysis

Operational tests are employing various methods to measure travel times, speeds, VMT, stops, and other traffic characteristics, including the use of 'floating' cars, instrumented vehicles, loop detectors, video surveillance systems, and automated data via control centers. The data are being used to perform both statistical analyses of impacts and to calibrate traffic simulation models. In particular, INFORM and Smart Corridor have developed detailed plans to evaluate impacts on traffic operations using multivariate analyses of data collected before, during, and after the implementation of signal coordination, ramp metering, and changeable message signs.

In contrast to direct measurements, SmarTraveler inferred impacts on traffic operations based on expected changes in travel behavior and mean travel times, distance, and speeds obtained from the local transportation planning agency. Guidestar Travlink, which plans to evaluate the impact of real-time public transit information, indicated that it may survey users to determine changes in trip lengths and VMT.

Models

The field tests plan to employ a variety of traffic simulation models, which are described below:

TRANSYT (ATSAC, PREDICT, APOLLON): TRANSYT is a well-known macroscopic traffic model, which simulates traffic flows through arterial networks and can be used to optimize signal timing plans. The model provides information on delays, average speed, number of stops, and queue lengths at links and intersections.44

INTEGRATION (TravTek, FAST-TRAC): INTEGRATION was developed to analyze the operation and optimization of integrated freeway/arterial traffic management, dynamic traffic control, and route guidance systems. TravTek used the model to evaluate the potential system-wide impacts of dynamic route guidance vehicles. The evaluators calibrated the model using actual traffic counts. FAST-TRAC recently used INTEGRATION to determine the number of probe vehicles required to effectively support ALI-SCOUT's (a dynamic traffic control system) vehicle-to-center communications capabilities.

TRAF-NETSIM, THOREAU: FAST-TRAC's original evaluation plan considered INTEGRATION, TRAF-NETSIM or THOREAU to simulate areawide traffic operations impacts. The latter two models are microscopic models, which simulate each vehicle's distinct speed-time profile. FHWA developed TRAF-NETSIM while the IVHS System Architecture teams are using THOREAU, developed by MITRE, to design and evaluate their user services.

RGCONTRAM (ROMANSE, Southampton, U.K.): RGCONTRAM is a microscopic model, enhanced by the Transportation Research Group at the University of Southampton. The model can simulate vehicles equipped with route guidance systems and distinguish between drivers who respond to information and those who ignore information or don't have access to it. The model can also produce incidents and estimate impacts of diversion strategies on traffic parameters.

VISUM (VICTORIA, Cologne, Germany): At the time of writing, the Volpe Center did not have enough information to describe this model's capabilities.

Emissions/Air Quality

Most of the operational tests, with the exception of a few European projects, plan to evaluate IVHS' impacts on vehicular emissions rather than air quality. In addition, the majority of tests lean toward model-based analytical tools rather than empirical methods to assess emissions impacts. The state-of-the-practice for empirical procedures and models is highlighted below:

Empirical methods

Infrared remote sensing (Environmental traffic control systems described in Table 2, ADVANTAGE I-75): The University of Denver developed infrared remote sensing devices, which can measure concentrations of CO and HC in tailpipe vehicle exhaust. Typically, the device directs an infrared beam across a single lane of roadway to distinguish an individual vehicle's exhaust emissions. Remote sensing has been used in a number of cities to determine the percentage of high emitting vehicles and their disproportionately high contribution to mobile source emissions.

LIDAR (First entry in Table 2): LIDAR is a laser based system that can be used to locate pollution sources and track the movements of plumes within a range of roughly ten kilometers. The systems are relatively new to transportation applications, although LIDAR has been used to track aerosol plumes in traffic environments in Albuquerque, Barcelona, and Mexico City. 46

Unspecified pollution monitoring (PREDICT, APOLLON): The PREDICT project, which demonstrated environmental management strategies in Athens, evaluated various pollution monitoring systems that could be used to ensure compliance with air quality standards, validate model predictions, and evaluate the effectiveness of traffic control and travel demand strategies. PREDICT also developed pollution monitoring plans for several European cities.

Models

MOBILE (ATSAC, SmarTraveler): EPA developed MOBILE to prepare mobile source emissions inventories for the State Implementation Plans. MOBILE provides emissions factors (grams per mile) for a vehicle fleet for any calendar year between 1960 and 2020. The model can evaluate impacts due to changes in number of trips and average speed as well as changes in a wide variety of external factors, such as temperature, altitude, fuels, inspection/maintenance programs, and emissions tailpipe standards. MOBILE is based on fixed driving cycles, most prominently the Federal Test Procedure. As a result, the model cannot predict the impacts on emissions caused by changes in traffic flow.

INTEGRATION (TravTek): For the TravTek evaluation, Michel Van Aerde developed emissions factors that could be coupled with the output of his INTEGRATION traffic simulation model. The model predicts CO, HC, and NOx emissions as a function of fuel consumption and is calibrated to a vehicle fleet using MOBILE5a. The model also incorporates procedures to account for changes in ambient temperature and cold starts. Van Aerde did not directly measure emissions to develop the model. 48

PREMIT (PREDICT, APOLLON): PREMIT is a European modal emissions model that estimates CO, HC, and NOx emissions as a function of cruise, acceleration, deceleration, and idling for different vehicle classes. The

model is integrated with a route assignment model (PDIAL), a traffic simulation model (TRANSYT), as well as an air dispersion model. APOLLON plans to adapt the model to estimate carbon dioxide emissions.

Unspecified developmental model (Smart Corridor): Smart Corridor plans to use an as yet undeveloped model that will predict emissions as a function of average speed, travel time, number of stops, total stopped time, and VMT.

Ford Corporate Vehicle Simulation Programme (ROMANSE, Southampton; VICTORIA, Cologne): The CVSP model, developed by Ford (U.K.), predicts modal emissions factors for new, well-tuned, gasoline passenger cars. The model appears to predict emissions as a function of cruise, deceleration, acceleration, and idle based on detailed vehicle engine maps that relate tailpipe emissions to engine load. The emissions model is integrated with a traffic queuing model (RGCONTRAM or VISUM) and an air dispersion model (UROPOL).

UROPOL (SCOPE, Cologne and Southampton): UROPOL is an air quality dispersion model used by the European SCOPE field tests. The model does not consider secondary reactions, but instead tracks plumes of pollutants based on meteorology and topology. Two other European projects, PREDICT and APOLLON, plan to use air dispersion models (which are unidentified) in their analyses.

Fuel Consumption

Strategies for evaluating fuel consumption impacts are less defined than for other impacts.

Empirical Analysis

Fuel logs (ADVANTAGE I-75): ADVANTAGE I-75 plans to assess energy impacts by comparing fuel use between trucks with and without weigh-in-motion transponders. The test may accomplish this by having drivers keep fuel logs, although the results may be confounded by differences in driving behavior. The evaluators may also compare the truck average fuel economy to that of trucks with weigh-in-motion systems.

Models

TRANSYT-7F (ATSAC): TRANSYT-7F predicts fuel consumption as a function of cruise speed, delay time, and number of stops. The latest version of the model calculates fuel factors for a 1983 average fleet mix.

INTEGRATION (TravTek): Michel Van Aerde calculated fuel consumption as a function of constant speed, idle, and velocity changes for use with the INTEGRATION model. The evaluators obtained actual fuel consumption data from a TravTek vehicle, a 1992 Oldsmobile Toronados, and planned to extrapolate results to a vehicle fleet using EPA's Highway and City fuel economy ratings.

Unspecified developmental model (Smart Corridor): Smart Corridor's evaluation plan states that it will use an as yet undeveloped model that will predict fuel consumption as a function of average speed, travel time, number of stops, total stopped time, and VMT.

Unspecified developmental model (APOLLON): APOLLON plans to adapt the PREMIT emissions model to estimate fuel consumption as a function of cruise, deceleration, acceleration, and idle.

ENVIRONMENTAL IMPACTS: RESULTS FROM FIELD TESTS

The Volpe Center identified a dozen field studies of IVHS user services, which have published their conclusions of environmental impacts. In general, the studies favorably view the potential benefits of IVHS technologies and strategies. The majority of studies evaluate well-known traffic technologies, particularly signal optimization. A description of the tests, evaluation methods, and results are summarized below by IVHS user service:

Dynamic Signal Control

The Volpe Center found nine studies that evaluate the environmental impacts of dynamic signal control. All of the studies show favorable impacts over conventional fixed-time traffic systems.

Automated Traffic Surveillance and Control Evaluation Study

Description: The Los Angeles Department of Transportation evaluated the Automated Traffic Surveillance and Control System (ATSAC) in 1987, three years after it was installed in the Coliseum area in June 1984. The ATSAC system included 118 signalized intersections and 396 detectors encompassing a four square mile area. 49

The purpose of the ATSAC system was to reduce congestion, travel times, energy use, and air pollution during the 1984 Olympic Games. The system incorporated 64 separate signal timing plans and optimized traffic flow with computer controlled signals by selecting the timing plan that best matched real-time surveillance data,

Evaluation: Because of resource constraints, the ATSAC evaluation limited its scope to a northwestern quadrant of 28 signals and 80 system detectors. The evaluators extrapolated results to the entire area under ATSAC control because "a large sample size was used and travel in the network [was] fairly consistent and uniform." The ATSAC evaluators did not collect data before the ATSAC system went into effect. Instead, the experiment simulated "before" conditions by temporarily implementing the timing plan that was used prior to ATSAC's implementation."

The evaluators of ATSAC employed three distinct and independent procedures to measure traffic operation performance. The first involved a travel time study, where several drivers traveled over prescribed routes and measured both travel times and number of stops. In the second method, the evaluators equipped a vehicle with an automated data collection device, which measured stops, travel times, and average speed. The third method obtained data directly from the ATSAC system. The ATSAC evaluators collected data during morning and evening peak periods during typical weekdays and daylight hours. In addition, the evaluators were careful not to collect data during bad weather days. The evaluators used the field data to calibrate a signal optimization model, TRANSYT-7F, which estimated system-wide impacts on traffic operations and fuel consumption.

Conclusions: The study concludes that ATSAC reduced HC, CO, and fuel consumption by 10.2, 10.3, and 12.5 percent, respectively." The evaluators calculated emissions impacts using factors obtained from EPA's MOBILE1. Fuel consumption results were obtained from TRANSYT-7F. In general, the emissions and fuel estimation procedures are appropriate, given the date of the study. However, the MOBILE model is not sensitive to traffic flow changes, but instead predicts emissions as a function of average speed for a fixed driving cycle. In addition, MOBILE's absolute emissions factors have increased significantly since the time of the study.

Australian Field Evaluations

Description: More than thirty cities world-wide have installed the Sydney Coordinated Adaptive Traffic System (SCATS) and similar systems. During the 1980s several Australian organizations evaluated SCATS in a number of cities. The Volpe Center obtained information on seven of these studies, which were performed in Sydney and Melbourne, Australia; Coventry, U.K., and Glasgow, Scotland.

Evaluation: The evaluators compared SCATS performance relative to no area traffic control and conventional fixed-time signal systems. At the time of writing, we had not obtained information on the experimental design, data collection process, and analytical methods employed for these studies.

Conclusions: The studies indicate that, on average, SCATS reduced travel times by 20 percent, number of stops by 93 percent, and aggregate fuel consumption by 14 percent compared to no area traffic control. Relative to fixed-time traffic control systems, SCATS reduced travel times by 4 to 8 percent, number of stops by 9 to 25 percent, and total fuel consumption by 6 percent relative to fixed-time signal control systems. 53

National Police Agency

Description: The National Police Agency is one of two agencies that have primary responsibility for implementing traffic safety systems in several Japanese cities. In 1993, the National Police Agency evaluated a traffic signal management system, which controlled timing for 80 streets. The system's goals were to improve traffic flows and "environmental quality." ⁵⁴

Evaluation: The evaluation compared dynamic signal coordination with conventional fixed-time signal control systems at three different levels: regional area control, street control, and isolated intersection control. To accomplish this, the evaluators collected field data before and after installing the dynamic control system, including traffic volumes (for 60 streets), travel time, queuing time, number of stops, and average travel speed.

Conclusions: The Volpe Center had access only to a summary of results for total area control. The study showed the following improvements: travel times (16 percent), queuing times (16 to 31 percent), number of stops (37 to 40 percent), and travel speed (20 percent). The evaluators estimated total annual fuel savings per intersection of 28 thousand liters. Fuel consumption impacts were calculated based on a linear relationship between fuel savings and average travel time. The study does not elaborate on the development of this algorithm or provide supporting references.

Traveler Information Services

SmarTraveler

Description: SmarTraveler, located in the Boston Area, provides commuters with real-time, location-specific traffic and transit information by telephone. The test has been operational since January 1993. The project encompasses 1.400 square miles, reaching 122 cities and towns around Boston in eastern Massachusetts. SmarTraveler's goals are to demonstrate public acceptance of real-time traveler and transit information, reduce congestion, increase mobility, and improve environmental quality.

Evaluation: SmartRoute Systems, the operator of SmarTraveler, commissioned a study of projected emissions impacts of the service in 1999. The study used a six step approach: (1) projected the use of SmarTraveler in 1999, (2) determined what percent of users will make changes in their trips, (3) determined how those trips will change, (4) determined the frequency of incidents that cause delay, (5) for a given changed trip, calculated the effects on VMT and speed, and (6) calculated resulting impacts on emissions. 55

SmarTraveler had previously surveyed users to ascertain response to the service. The survey revealed that 96 percent of users changed the time, route, or mode of their travel at least occasionally, while 30 percent of the users changed the time, route or mode of their travel frequently. Because the survey was not designed for emissions evaluation, it did not disaggregate mode, route, or travel time changes. As a result, the evaluators inferred that 50 percent of users changed route, 45 percent changed time of travel, and 5 percent changed mode of travel based on a study of a similar traveler information service in Seattle. The study used 1990 statewide census data to determine the VMT and average speed characteristics of morning commutes by single occupancy vehicles to the Boston Central Business District. The study obtained data on accidents, breakdowns, and roadway construction from the SmarTraveler system. The study calculated absolute impacts of the SmarTraveler project in 1999 on total volatile organic compounds (VOC), CO, and NOx by predicting impacts on VMT and speed resulting from expected changes in travel behavior and avoided delay.

Conclusions: The study estimates that SmarTraveler could reduce summertime CO, VOCs, and NOx in 1999 by an average of 5032, 498, and 25 kilograms (kg) per day, respectively. The range of calculated emission reductions in 1999 were estimated at 2,726 to 7,338 kg/day for CO, 270 to 726 kg/day for VOC, and 14 to 36 kg/day for NOx. Emissions impacts were calculated using EPA's MOBILE5a emissions model. 57

Vehicle Route Guidance

Comprehensive Automobile Traffic Control System

Description: The Comprehensive Automobile Traffic Control System (CACS) was completed in Tokyo in 1979 at the conclusion of a large scale field experiment of in-vehicle dynamic route guidance, which was conducted from 1977 to 1979.⁵⁸

Evaluation: The experiment was conducted in a 30 square-kilometer area in southwest Tokyo, which included 103 intersections. Route guidance information was provided to 300 vehicles, which had two-way communication capability. The literature does not elaborate on the specific experimental design, data collection, and modeling methods.

Conclusions: The feasibility study on the guidance systems concludes that CACS reduced CO, HC, and NOx emissions by 6.5, 6.2, and 0.4 percent, respectively. The evaluators also estimated 3 to 7 percent improvements in fuel economy. The literature states that emissions estimates were calculated using simulation models, but does not name or describe the models while fuel savings were calculated using "the relationship between gasoline consumption and vehicle speed", which again is unspecified. The study provides very limited information about data, assumptions, and methodologies for estimating emissions and fuel impacts.

Environmental Management Systems

PREDICT

Description: PREDICT was a field demonstration of environmental optimization of traffic signal timings, pollution-sensitive traffic rerouting, "clean" cars, and environmental area licensing in Athens, Greece. The goal of the project was to improve air quality while optimizing traffic flow.

Evaluation: PREDICT used a four-element "model suite" consisting of a traffic assignment model (PDIAL), a traffic model (TRANSYT), an emissions model (PREMIT), and an air dispersion model (unnamed) to evaluate air quality impacts, The PREDICT suite modeled traffic activity at the microscopic level and accounted for changes in traffic flow patterns as well as fleet composition. In addition, the project developed an additional module that predicts the human health effects of different ambient air pollution concentrations. PREDICT also evaluated the appropriate use of air pollution monitoring in traffic control operations.

Conclusions: The evaluators concluded that the demonstrated technologies could reduce vehicular emissions by 4 to 50 percent. The Volpe Center has not yet obtained information to differentiate impacts of each user service.

Routing and Scheduling Optimization Systems

Case Studies of Commercial Operations

Description: Latshaw and Nulty performed eight case studies of routing and scheduling optimization used in diverse commercial operations, including newspaper delivery, warehouses, dairy distribution, mail delivery, farm product shipment, consolidation of a utility cooperative, beverage products distribution, and grocery delivery. ⁵⁹

Evaluation: The case studies evaluated the affect of routing and scheduling optimization on trips, VMT, travel times, number of stops, and resulting impacts on emissions. The study concluded that optimization technologies reduced VMT by 5 to 20 percent, although for one warehouse consolidation case study, VMT increased as did emissions.

Conclusions: The study extrapolated case study results to the national level to conclude that the techniques could "reduce the National mobile source oxides of nitrogen emissions by 250 to 1000 tons/day along with reduction in other types of pollutants." ⁶⁰ At the time of writing, the Volpe Center did not have access to information describing the techniques used to obtain either traffic data or emissions estimates.

CONCLUSIONS

Implications of Operational Tests

The field tests with published results indicate favorable environmental impacts of IVHS user services. Most of these tests address more conventional traffic management user services, particularly dynamic signal coordination. However, tests demonstrating traveler information and, especially, public transportation user services are not well represented.

The evaluation plans for most of the field tests investigated to date focus on technical feasibility and, to a lesser extent, user response. Because most of the tests have multiple objectives, environmental evaluations are subject to the optimization of other evaluation strategies. In addition, in the United States, a number of the tests are struggling to identify appropriate data collection and analytical techniques to estimate emissions and fuel consumption impacts. Those operational tests that are evaluating environmental impacts have employed or will use dissimilar methods, which will make it difficult to compare IVHS user services. However, given the infancy of the national IVHS operational test program, a standard may naturally evolve as more field tests, such as TravTek, complete and publish their evaluations.

In contrast to the United States' emphasis on individual, autonomous projects, Europe is developing programs to steward the environmental evaluations of IVHS field tests and to facilitate sharing of knowledge and experiences among tests. These programs also ensure that resources are dedicated to assess energy and air quality impacts of diverse IVHS user services. The European programs, upon closer scrutiny, may provide an alternative paradigm for evaluating the environmental implications of operational tests.

Future Work

The Volpe Center will complete its investigation of the environmental practices of the operational tests in early summer 1994. In conjunction with this work, we are developing a guidebook that will attempt to reduce the complexities of emissions and fuel consumption evaluation into manageable components that address exogenous variables, travel activity, traffic operations, and emissions and fuel use dynamics. The guidebook will propose experimental designs that capture, as much as possible, the causal relationships between these components. The intent of the guidebook is to recommend flexible, best practice options to accommodate pragmatic concerns of time and resources.

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ENDNOTES

- I. The minimum number of nationally funded operational tests is 400. This figure is a composite estimate derived from several sources. The estimate, therefore, is not exact, but does suggest the scope of IVHS field tests.
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 - 30. Ibid., p. 6-8.
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IVInstitutional **Issues**

INTELLIGENT VEHICLE-HIGHWAY SYSTEMS (IVHS): ECONOMICS AND ENVIRONMENTAL POLICY

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ABSTRACT

This paper considers the environmental impacts of IVHS from an economic perspective. It discusses the potential public and private benefits of IVHS technologies and the role of the public sector in the development of smart cars, smart streets and smart transit. It concludes that some IVHS technologies can promote *technological* efficiency but that *economic* efficiency requires the use of policies that target the externality costs associated with automobile use.

INTRODUCTION

Intelligent Vehicle-Highway Systems (IVHS) are intended to offer a variety of technological solutions to the nation's growing surface transportation problems.' IVHS are a set of potential, new technologies designed to alleviate congestion and, in effect, increase road capacity, primarily by re-routing and smoothing traffic flow. Currently, IVHS activities are in various stages of research and development, operational testing and deployment (FHWA and FTA 1992). Federal legislation has allocated well over \$100 million annually to these projects and eventual cost of IVHS deployment may reach the hundreds of billions of dollars (Horan and Gifford undated).

The public sector has traditionally accepted responsibility for transportation infrastructure investment because of the public services provided. However, although IVHS deployment involves large infrastructure investments, including traffic surveillance and communications systems, the benefits provided will be both private and public to varying degrees. In addition, because successful deployment of IVHS technologies require the financial base, marketing capabilities and technological expertise found in the private sector, a partnership is developing between the public and private sectors for the purpose of achieving IVHS deployment (FHWA 1992). These facts raise policy questions concerning the role of public sector involvement in IVHS deployment.

This paper discusses the potential, public and private benefits of IVHS technologies and discusses the role of the public sector in the development of smart cars, smart streets and smart transit.' The stated purpose of IVHS is to effectively expand roadway capacity, allowing more people to use the roads and travel faster than before, a public benefit. But the surface transportation system as a whole imposes large public costs, including congestion and environmental externalities, that might be exacerbated by the increased automobile use that IVHS is expected to encourage. This paper addresses the policy implications of IVHS implementation, particularly with respect to environmental quality.

The next section discusses two concepts in the economics of transportation that are relevant to this discussion: externality costs and latent demand. Section 3 draws on this discussion as well as theoretical research about the travel behavior implications of IVHS technologies and empirical evidence about travel behavior to assess the public and private benefits of smart cars, smart streets and smart transit. It asks whether public sector investment is appropriate for the IVHS technologies considered here. Public sector investment is appropriate when public benefits are sufficiently large relative to the cost of program implementation. As we consider IVHS implementation, we must also address the external costs associated with the potential increase in automobile use. Section 4 focuses on environmental policies for transportation and discusses their relationship to IVHS policy. Section 5 summarizes the key points of the paper.

ISSUES IN TRANSPORTATION POLICY

The Social Cost of Driving

According to economists, the problem with automobile use is that automobile users do not pay for the time delay and environmental costs they impose on others. The costs of automobile use can be divided into two categories: private costs and public (external) costs. Private costs are those actually borne by the driver and consist of gasoline costs, parking fees, road tolls, wear and tear on the automobile and the opportunity cost of travel time. External costs include congestion costs (the increased time spent by others on the road as a result of the marginal increase in congestion created by an additional car), air, water and noise pollution, increased risk of traffic accidents and increased deterioration of the roads. The sum of private and public costs is the full social cost of driving. Individuals weigh their own, private costs against the benefits they anticipate from driving to determine how much driving they will do. Because their driving produces external costs, the result is a market inefficiency where total social costs exceed total (mostly private) benefits. A recent estimate suggests that time delay costs alone exceed \$22 billion annually (Hanks and Lomax 1991).

Latent Demand

The question of how IVHS will affect the social burden of environmental and congestion costs is a complicated one. IVHS is targeted at the congestion problem and is intended to decrease travel delays. This effect decreases part of the privately-borne cost of driving and promotes automobile use, increasing both vehicle miles traveled (VMT's) and number of trips. This is a phenomenon known *as latent demand*

Latent demand refers to the additional, unanticipated vehicles that appear on new roads because people switched routes, modes or travel times, or because they decided to take trips they had previously not taken. Latent demand is present when congestion is *severe* enough to deter people from taking trips using their most preferred routes, modes or times of day. When new road capacity becomes available, these people switch to their more preferred trip plans and might even cause congestion to return to its previous level? Note however, that although travel times may not improve, more people are taking more convenient trips than before. This is an economic gain that should not be ignored when evaluating plans to increase road capacity. From an environmental quality perspective, however, more cars, which might be traveling at the same slow speeds as before, generally means more emissions.

A full assessment of the costs and benefits of using IVHS to reduce congestion therefore requires an understanding of the extent to which latent demand will offset travel time gains. Most reports of latent demand have been based on ex *post* studies. For example, Sherret (1975) found that after the Bay Area Rapid Transit (BART) opened in the San Francisco Bay Area, 8,750 transbay trips were diverted to BART, but 7,000 new automobile trips were generated. Using the *stated preference* approach to estimating latent demand, Kroes et al. (1987) found that latent demand in western Holland would add 27% to the existing evening peak hour traffic.

To date, Henk (1989) seems to have provided the most comprehensive study estimating and predicting latent demand for the state of Texas. Using data from before and after new roads were introduced in 34 selected study sites in Texas, Henk (1989) finds that the existing volume to capacity ratio (an indicator of the severity of congestion) and nearby population density positively affect the magnitude of latent demand. For example, in his study, a percentage increase in volume to capacity increases latent demand by around 90 vehicles. Latent demand can be as high as 13.8 times the population density depending upon whether the new road crosses a natural barrier, is a freeway and is radial rather than circumferential.

It is impossible to make a general assessment of how much latent demand IVHS would induce because latent demand is clearly a location-specific phenomenon. However, Henk's (1989) model and the BART example suggest that in areas where congestion is particularly severe, latent demand is likely to be high enough to offset a large percentage of the travel time gains created by new road capacity.

ECONOMIC IMPACTS OF IVHS

This section summarizes the main types of IVHS technologies and evaluates the primary expected impacts based on the incentives created. A convenient way to review IVHS technologies **is** to refer to three general categories: "smart cars," "smart streets," and "smart transit." Smart car technologies refer to privately owned technologies that are installed in individual automobiles such as Advanced Traveler Information Systems (ATIS) and Advanced Vehicle-Control Systems (AVCS). ATIS are intended to provide the driver with real-time information about traffic conditions and optimal route-planning. AVCS are intended to provide automatic steering and braking controls that allow closer following distances and faster speeds. Smart streets refer to Advanced Traffic Management Systems (ATMS) which are infrastructure-based monitoring systems intended to be used for traffic smoothing and accident detection. Smart transit technologies include real-time transit schedule information and high-tech fare cards which are intended to make transit systems more attractive relative to automobiles.

Smart Cars

Smart cars are intended to reduce congestion by providing people with real-time information about road conditions and better vehicle control systems. Implementation of ATIS involves large infrastructure investments in traffic monitoring and communications systems as well as individual information dissemination units which may take the forms of at-home telephone subscriber services or in-vehicle technologies. AVCS are primarily in-vehicle technologies.

Some ATIS owners, upon learning of congested conditions, will presumably choose to travel using alternate routes, modes or times of day, or maybe even forgo their trips altogether. The intended result is that overall travel times are reduced. Arnott, de Palma and Lindsey (1991) have shown, however, that this might not be the case. They use a general equilibrium framework to consider how providing information to travelers will affect expected travel times and find that there are many potential outcomes depending on the number of travelers receiving information, how they react to information, how they expect others to react and how reliable the information is. One possible outcome, for example, is that when people learn of congested conditions, they postpone their trips only to cause congestion when they all get on the road at a later time. Arnott, de Palma and Lindsey (1991) also find that the per vehicle, private benefits are greatest when information is provided to only a few individuals and private benefits decrease as the number of individuals receiving information increases. When all individuals are equally informed, travel times can even increase.

It is important to point out that during periods of recurring congestion people will have already optimized their trip routes and timing to deal with congestion. In other words, people will have already sorted themselves out so that those who experience the highest costs from congestion have found ways to alter their routes or timing and those who are more willing to bear the congestion costs stay on the congested roads during these times. Adding new information to this long-run equilibrium might not alter the amount of congestion that exists.

It is estimated that as much as 60% of congestion is non-recurring (Lindsey 1989); but non-recurrent (incident-related) delays occur because highways are overloaded to start (Hall 1993). Traffic diversion therefore requires surplus capacity on nearby alternate routes. During congested times, this capacity might not be available. Al-Deek and Kanafani (1993) show that although guided traffic is better than unguided traffic in situations of non-recurring congestion, the benefits associated with traffic diversion are mitigated by the congestion that is bound to form on the alternate routes. In fact, they suggest that there are little, if any, benefits associated with guiding traffic during peak periods, the most important periods to target.

The results in the literature seem to suggest that smart cars are most effective in situations where only a few individuals have them. If this is true, then there will be few public benefits associated with smart cars and the marketplace can take care of optimizing total net (private) benefits. Drivers who see potential benefits exceeding the costs will purchase the technologies. The purchasers of smart cars will be those who place the highest values on time, and as more smart cars appear and benefits diminish, purchases will slow down. The result should be an optimal allocation of smart car technologies that maximize net private benefits. Because smart car technologies offer primarily private benefits, they should be produced and sold as private market goods that may have a small public benefit associated with them.

Some might argue that although it is practical for the private sector to provide individual units of smart car technologies, it is still public sector responsibility to provide the traffic monitoring infrastructure (see FHWA 1992). This, however, is not the case. If the private benefits of smart car technologies exceed the full cost of implementation, then private firms will find it profitable to invest in infrastructure as well as equipment development. If they do not find it profitable, then it would be a poor investment for the public sector as well. The potential public benefit does not appear to be large enough to warrant government subsidization of smart car technologies.

Smart Streets

Advanced traffic management systems (ATMS) are sometimes called "smart streets." They include technologies for on-road surveillance and control of traffic flows through signal synchronization and ramp-metering systems, among other things. Preliminary testing of these systems has found time savings in several cities. For example, estimated improvements from ramp metering systems have shown increased speeds of 35% with increased throughput of 32% in Minneapolis-St. Paul and reduced travel times of 48% with increased throughput of 62-86% in Seattle (Federal Highway Administration 1989, cited in Shiladover 1993). The automated traffic surveillance and control system (ATSAC) in the City of Los Angeles has measured improvements of 13.2% in travel times, 14.8% in average speed and 35.2% in fewer stops (Rowe, Okazaki and Hu 1987, cited in Shiladover 1993).

As mentioned earlier, improving traffic flows will induce latent demand which, over time, might counteract the congestion and emissions benefits measured in these examples. Still, there are benefits associated with getting more people where they want to go at the times of day they prefer.

Because ATMS are intended to accomplish travel time reduction by traffic re-routing and smoothing, one of their side effects might be a reduction of VOC emissions per VMT. The anticipated result is that we have more cars traveling at faster and less-erratic speeds, perhaps producing fewer emissions per VMT than before. Unfortunately, we do not yet fully understand the relationships among VMT's, number of trips (cold starts), speed and emissions so we cannot unequivocally say whether or not emissions or other automobile-related externalities increase or decrease as a result of ATMS implementation (Sperling et al. undated). Smart streets appear to promote system efficiency, a public benefit, but the overall externality impacts, especially environmental impacts, remain an empirical question.

It is useful here to distinguish between technological and economic efficiency. Technological efficiency refers to the engineering aspects of a system rather than the allocative aspects. If there are bottlenecks in the system, then there are potential gains associated with alleviating these bottlenecks. These gains are separate from the question of whether we have too much traffic to start. We do not promote economic efficiency by maintaining the bottlenecks and allowing excessive travel times to discourage people from driving.

ATMS are meant to target technological efficiency, and when evaluated on this basis, they seem to potentially offer substantial, public benefits, warranting public sector investment. In light of the potential increase in automobile use these technologies encourage, however, it will become even more important to pursue policies that target environmental externalities.

Smart Transit

Smart transit is intended to improve the attractiveness of transit primarily by providing real-time information to travelers about transit schedules. This should reduce wait times which are known to be considered negative attributes of transit. Smart cards will offer riders convenient payment methods without having to carry exact change. Smart transit is often used as the primary example of how IVHS will help diminish transportation's negative environmental impacts. The idea is that increasing the attractiveness and accessibility of transit increases its use and decreases automobile use and VMT's.

Unfortunately, expectations in this regard are probably overly optimistic." It is clear fi-om the results of research on mode choices that transit is considered an inferior option compared to the automobile for most

transportation users. Most transit systems presently make up less than 2% of the mode share in their respective cities. Inducing a significant reduction in automobile use would require a more than tripling of transit use in such cities, a difficult goal to achieve.'

Because the primary benefit of smart transit is reduced transit wait time, we can look at empirical models of mode choice that include transit wait time or transit headway time (the scheduled time between transit vehicle arrivals; wait time is often assumed to equal one-half of the headway time) in order to get an idea of how smart transit could increase transit ridership. Train (1980) for example, estimates mode choice and vehicle ownership for work trips in the Bay Area using a multinomial, nested logit model (McFadden 1973, 1978) and includes separate variables for transit headway and in-vehicle times. We can estimate an elasticity representing the percentage change in the probability of choosing transit with respect to a percentage change in transit headway time (Train 1986, p. 40). This elasticity is a function of the probability of choosing transit, the transit headway time and the estimated coefficient on transit headway. Using Train's (1980) estimation results, we find that the elasticity is -0.2 1 when the transit headway time is 10 minutes. For example, the probability of choosing transit increases 2.1% when headway time is reduced from 10 minutes to 9 minutes (a 10% change). Transit use in the Bay Area sample is estimated to be 19% of work trips (an unusually large mode share), so a 2.1% change in the probability of transit use would increase the transit mode share by 0.4%. Note that if we applied the same elasticity to a low-transit-use city, the magnitude of the increase in transit use would be much smaller than this. Reducing transit wait time through smart transit will increase transit use but not by amounts large enough to significantly reduce VMT's.

Nevertheless, improving transit, if coupled with a policy that provides a disincentive to drive, can offer substantial benefits. Price elasticities for automobile use have been shown to range between -0.1 and -0.5 (Goodwin 1992, Oum, Waters and Yong 1992). Improving the attractiveness of transit could increase the magnitudes of these elasticities by offering more viable substitutes for the automobile. Smart transit could be an important policy complement to environmental pricing.

Summary of Results

Table 1 summarizes the potential public and private benefits anticipated from investments in smart cars, smart streets and smart transit and the appropriate role of public sector investment.

This section has argued that the three broad categories of IVHS will have differing economic and environmental impacts. Smart cars will primarily offer private, time-savings benefits and should therefore be developed and sold in the private sector without public support. Smart streets will offer public benefits by allowing more people access to the roads at peak times, but in the absence of countervailing pricing policies, might negatively affect the environment by increasing VMT's and number of trips. Smart transit will offer marginal public benefits, including environmental benefits, by encouraging transit use instead of automobile use. The effectiveness of smart streets and smart transit could be enhanced by policies that discourage automobile use. Some potential policies are mentioned in the next section.

IVHS AND ENVIRONMENTAL POLICY

The stated purpose of IVHS is to effectively expand roadway capacity through the use of technology. This is indeed an important goal given the high and growing costs that congestion imposes on society." But because the surface transportation system as a whole harms the environment, this stated purpose seems to be directly at odds with the environmental goal of reducing emissions." Even if IVHS does not adversely affect the environment, it is probably not the most effective policy for pursuing environmental improvement. A basic notion in economics is that the best way to pursue a policy goal is to target that goal directly (Baumol and Oates 1988). In the case of transportation policy, we seem to have two opposing goals: to move people as efficiently as possible given the present transportation infrastructure (technological efficiency) and to reduce transportation-related externalities (economic efficiency).

Ideally, the notion of moving people as efficiently as possible would incorporate both goals simultaneously. Efficiency implies least cost, and if we forced people to pay the full cost of driving, we would indeed obtain an

efficient solution that balances the benefits associated with automobile use with the full social costs, including congestion and environmental externalities (Baumol and Oates 1988). But the present system is far different from this economically ideal world. People do not pay the full cost of their driving and it is not clear that they will do so anytime soon."

In our non-ideal world, it makes sense to pursue the goals of technological and economic efficiency using a mix of policies where each goal is targeted directly using the appropriate mechanism. Following this prescription, it can be argued that some IVHS technologies show promise in promoting technological efficiency (reducing travel times or increasing throughput) while other policies such as congestion pricing or emissions testing can be used to combat the serious environmental problems created by the system as a whole, promoting economic efficiency. In other words, the idea of getting more people where they want to go faster than before is a public benefit." The fact that at present, people are not paying for the costs they impose on society when they drive generates a large public cost. These costs must be addressed using appropriate policies, especially as we consider introducing IVHS technologies which might exacerbate some of these costs.

There is a growing literature evaluating emissions-related policies including reformulated gasoline, enhanced inspection and maintenance programs, alternative fuels, congestion pricing, gasoline taxes and accelerated vehicle scrappage programs (Alberini et al. 1993, Geoghegan et al. 1994, Harrington, Walls and McConnell 1994, Krupnick 1992, Krupnick, Walls and Hood 1993, Walls 1992). Harrington et al. (1994) find that, in general, policies that rely on economic incentives, such as emissions rate-based vehicle registration fees, and target high emissions rates, such as vehicle inspection and maintenance programs, are more cost-effective than technology-based policies, such as alternative fuel vehicles and California emissions standards.

If we are interested in targeting automobile-related emissions we must design policies that create the appropriate incentives. The cost-effectiveness of a program depends crucially on the ability of a program to target high-emitting vehicles, especially those that are heavily used. In addition, to maximize benefits, it is important to focus on critical areas, at critical times of day, during critical seasons. It may be impossible to develop one program to satisfy all of these criteria at once, but it is clear that certain programs are more likely to create the appropriate incentives for high-emitting vehicle owners. For example, Harrington et al. (1994) recommend an emissions ratebased vehicle registration fee coupled with a VMT-based fee, which would focus both on emissions rates and amount of vehicle use and encourage owners of these vehicles to maintain them properly and/or drive less.

Pricing policies such as gasoline taxes and congestion pricing are advocated by economists because they directly target externalities by increasing the privately borne costs of automobile use. Gasoline taxes, however, do not focus on congested areas and times and therefore might result in more diffuse emissions and congestion reductions that might not bring large marginal benefits (Krupnick et al. 1993). Congestion pricing is primarily intended to reduce congestion costs but also has the benefit of reducing the higher VOC emissions associated with congested conditions. Recent empirical work by Geoghegan et al. (1994) Mohring and Anderson (1994) and Repetto et al. (1991) has shown that optimal congestion fees can substantially reduce congestion and emissions costs and produce significant public benefits.

It is beyond the scope of the present paper to review the aforementioned environmental policies in detail. They are mentioned here as policies that directly target emissions and can be used in conjunction with certain system efficiency-enhancing IVHS programs. It should also be noted that IVHS technologies can be used to facilitate implementation of some of these environmental policies. Advanced Vehicle Identification (AVI), for example, can facilitate road tolling for congestion pricing. AVI might also be used in association with remote emissions-sensing devices to fully automate an emissions rate-based pricing scheme.

CONCLUSIONS

The purpose of IVHS is to effectively expand roadway capacity through the use of technology. Based on preliminary test results and theoretical reasoning, it appears that the programs with the highest potential for improving public benefits are ATMS. Preliminary tests show potential for improving system efficiency by increasing throughput and possibly, reducing travel times (depending on the amount of latent demand induced). ATMS, like

most IVHS technologies, will encourage automobile use so that total VMT's will increase, making it possible that congestion will return to its original level. But the external costs associated with VMT's and congestion should be addressed using policies targeted directly at these problems.

Smart transit technologies are said to enhance the attractiveness of transit and encourage its use over the automobile. Based on mode choice estimation results and existing mode shares, however, it is not clear that these technologies alone will achieve significant reductions in automobile use. But when combined with pricing policies that discourage automobile use, smart transit might be appropriate and even necessary, depending on the cost of implementation.

Smart cars seem to offer mostly private benefits. These technologies should therefore be developed and sold in the private sector without public participation in their development.

The approach taken in this paper is to consider IVHS technologies in a broad sense. Within the categories discussed, there are specific ideas, not mentioned here, that might warrant special consideration, such as smart vanpools or smart communities. There might also be complementarities associated with particular combinations of technologies.

The purpose of the present paper is to discuss IVHS in a policy context, looking at public and private costs. IVHS will not solve all of our transportation problems and might even exacerbate some, especially environmental costs. We must therefore begin to think comprehensively about an overall transportation policy mix that addresses both system inefficiencies and economic inefficiencies.

IVHS Technology	Description	Potential Public Benefits	Potential Private Benefits	Appropriate Role of Public Sector
Smart Cars	- Route Guidance (to avoid congestion) - Automatic vehicle controls	- Small reduction in congestions and travel times - Uncertain effect on total VMT's and emissions	Large travel time savings by avoiding congestion	Leave all investments to private sector
Smart Streets	Infrastructure-based systems to control and smooth traffic	More road capacity that allows more people to travel when and where they want	Latent demanders get access to roads	Invest when public benefits are greater than implementation costs
Smart Transit	- Real-time transit schedules - Easy payment methods	Very small improvements in congestion and emissions	More convenience for transit users	- Invest only where potential transit ridership might substantially increase - Consider as complement to a pricing policy

Table 1: Potential Benefits of IVHS and Role of Public Sector

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ENDNOTES

- 1. Assistant Professor at the Hubert H. Humphrey Institute of Public Affairs, University of Minnesota, Minneapolis, and visiting Gilbert White Fellow at Resources for the Future, Washington, D.C. The author would like to thank Anna Alberini, Jacqueline Geoghegan, Winston Harrington and Margaret Walls for helpful comments on an earlier version of the paper and takes full responsibility for any remaining errors.
- 2. See Downs (1992) and Small et al. (1989) for discussions about trends in transportation use, congestion, environmental costs and infrastructure constraints.
- 3. Unfortunately, because IVHS technologies are new and untested, it is impossible to make a reliable quantitative assessment of the economic and environmental impacts of IVHS. Instead, many researchers have evaluated aspects of the IVHS program on a qualitative basis. or recommended research directions or methodologies to aid in making quantitative assessments in the future (Horan and Gifford undated. Shiladover 1993, Underwood and Gehring 1992). This paper performs a qualitative analysis.
- 4. In the long run, people may choose where to live or work based on new road capacity, so the full extent of increasing road capacity may not be seen until many years after implementation.
- 5. The high cost of smart cars will prohibit most people from purchasing them. This has led to concern about equity issues. This concern is valid when the public sector is subsidizing development and production, but would not be an issue should ATIS become a purely free-market good.
- 6. Shiladover (1993) for example, suggests that smart transit could improve greenhouse gas emissions by 10% to 30%.
- 7. Furthermore, an inordinate increase in ridership might require larger transit operations which might impose increased environmental costs in some cities.
- 8. The elasticity decreases as the headway time decreases, so multiplying the 0.4% effect by 10 minutes would overestimate the amount of transit use resulting from a complete elimination of wait time. Thus, 4% is an *upper bound* of the increase in transit mode share.
- 9. Congestion has been estimated to be roughly equal to one-third of the total social cost of driving (Small 1992, p. 84)
- 10. The nation's surface transportation system presently contributes 70% of carbon monoxide (CO), 39% of nitrogen oxides (NO,), and 30% of volatile organic compound (VOC) emissions (USEPA 1992). In urban areas that violate the National Ambient Air Quality Standards (NAAQS) the shares of automotive emissions are even higher.

- II. There has been increased interest in the idea of congestion pricing which would charge drivers for the congestion externality they impose. The Intermodal Surface Transportation Act (ISTEA) of 199 1 includes funding for congestion pricing pilot projects. At present though, there is only one pilot project underway (in the San Francisco Bay Area) and it may be years before implementation occurs.
- 12. Small (1992, pp. 36-45, 77) suggests that travel time for work trips is typically valued at 50% of the wage, or approximately \$4.80 per hour for the U.S. in 1989. This information, in association with a location-specific estimate of latent demand, can be used to approximate the public value of increasing road capacity and possibly reducing travel time in a particular location.

IVHS AND PUBLIC PARTICIPATION: CHALLENGES, OPPORTUNITIES AND NEW MODELS FOR COOPERATION

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INTRODUCTION

The nexus of Intelligent Vehicle-Highway Systems (IVHS) and the environment presents a significant challenge for public policy makers. Competing visions of appropriate investments in new technology and great uncertainty over possible environmental impacts are key concerns. As IVHS moves closer to deployment, consideration is being given to the regional planning process; yet little discussion has addressed strategies for public involvement as mandated by the Intermodal Surface Transportation Efficiency Act (ISTEA).'

This paper identifies several key challenges to creating an informed public discourse about IVHS planning in a regional context. Based on relevant literature, policy consultations held in three cities, and related interviews, the paper also describes evolving parameters for cooperation and suggests new models for cooperation. By models for cooperation, we mean ways of increasing understanding within and among three interdependent world; politics, institutions and citizens. This paper focuses primarily on the citizen sector. Future work will expand on the political and institutional sectors and elaborate on new models of cooperation across sectors.

We identify five components of new models for cooperation; 1) aggressive stakeholder involvement, 2) public outreach/education, 3) coalition building both within and across sectors, 4) integrating new technologies with existing projects and policies, and 5) built-in cost-effectiveness analysis that considers least cost/full cost accounting and evaluation of strategic economic investments.

Three Interdependent Worlds

The political world. While politics is a mysterious terrain for many people, it is really not that hard to understand. Politics is a marketplace, where ideas and perceptions are translated into laws and budgets. The currency is votes -- votes to get elected and votes to pass laws and make public investments. As with any market there are cycles, misinformation, speculation, and good and bad decisions.

The institutional world. Large and small, long-term and short-term organizations are included in our definition of institutions. An institution is created to achieve a specific mission, which may be to serve the public's transportation needs or to improve the environment. Public and private institutions, including public interest groups, shape the way we perceive and address public issues. Public policy problems are becoming increasingly more complex, requiring organizational missions to be redefined and expanded, new partnerships and new ways of crossing institutional boundaries.

The Stare and Local Policy Program of the Humphrey Institute of Pubhc Affairs is conducting a study of new models for cooperation in the application of advanced transportation systems for environmental improvements in urban areas. The study focuses on three case studies En Houston. Texas: Minneapolis-St. **Paul**, Minnesota: and Portland, Oregon. (The results of these three case studies were presented in a paper presented at the IVHS AMERICA annual conference in Atlanta m April.)

The citizen world. The job of political leaders and public institutions is to address the concerns of citizens, but this is easier said than done. Citizens can be amazingly fickle when it comes to public policy. As citizens, we each bring our individual needs and biases to the table. Citizens act as customers who place mobility and service demands on transportation systems. But citizens are also concerned about the effects of public policies in the long-run and may be willing to change behavior if they see long-term benefits to the environment and future generations.

I) THE POLITICAL WORLD:

Congressional support for IVHS investments and environmental policies reflects several different and sometimes contradictory interests.

Jobs and Economic Development. While the total number of U.S. jobs have been increasing and the unemployment rate is down, jobs remain the most potent political issue nationwide. Americans feel less job security, less opportunity for advancement and better pay, and more concern about future jobs for their kids. The Congressional support for IVHS funding draws heavily from members' interest in creating and sustaining jobs, competing globally, improving the efficiency of public investments, and converting defense industries to civilian markets to reduce economic dislocation.* Congressional interest was especially motivated by spending and progress in IVHS in Europe and Japan.

Environment and Sustainability. During the past decade environmental problems have moved from peripheral concerns to mainstream political issues. Vice President's Al Gore's bestseller *Earth in the Balance* is one example of this trend.

Environmental issues are intensely political when they become local and the "not in my back yard" (NIMBY) phenomenon takes hold. Supporters of environmental improvement (and policies to encourage sustainable development) are more knowledgeable, articulate and effective in influencing public policy than they were a decade ago. Further, members of the generation born in the 1960's and 1970's, who place great importance on environmental quality, are beginning to take important staff and leadership roles that will shape public policies.

Economic Polarization. Social equity issues are increasingly important to many public policy makers. Concerns that Americans are becoming more polarized economically, socially and geographically are borne out by the 1990 Census data. While there are many causes for this polarization, past transportation policies have contributed to the geographic isolation of disadvantaged groups. The interstate system made it easier and less costly for the more affluent to move to suburbs far from the urban core **and** for businesses, particularly manufacturing, to locate on the edges of urban areas. This resulted in a locational mismatch of job opportunities for those who need them most, reducing access for lower income citizens. Transportation policy alone cannot resolve the problems of economic polarization, but is likely to be an essential component of emerging solutions.

Community Involvement. During the 1970's and 1980's a wide-range of neighborhood and community-based groups emerged to represent the concerns of citizens in the public arena. To a certain extent, these voluntary groups replaced the role of traditional political parties in representing the concerns and day-to-day problems of citizens to government. Many current political leaders started with grass-roots community organizations and still view these community-based groups as their primary political base. While many of these community-based organizations emerged on the basis of a single issue (frequently a transportation issue such as opposition to a new freeway), these organizations now cover a broader range of neighborhood and community issues, and they have become more effective in the policy arena. State and local transportation departments are now more sensitive to the need for community involvement and actively seeking better ways of incorporating citizen input.

II) THE INSTITUTIONAL WORLD:

The emerging consensus on transportation policy is being shaped by diverse coalitions of institutions committed to long-term change. ISTEA was the result of a coalition, including the leadership of USDOT, environmental and community interests represented by the Surface Transportation Policy Project and traditional transportation interest groups. Building and sustaining these coalitions at the state and local level will be particularly important if the expectations of ISTEA are to be achieved.

Provisions of ISTEA likely to have a profound impact on transportation policy in future years include:

- 1) **Decentralization of Decision-making.** ISTEA shifts responsibility for setting transportation priorities from the federal to state and regional levels. This results in increased flexibility but also requires a greater local capacity for planning and a much higher level of coordination and cooperation among all levels.
- Cooperation Across Institutional Boundaries. ISTEA requires, or encourages through funding flexibility, cooperation across transportation modes, federal, state and local organizations, and agencies representing other public functions; and with the private sector. State and local transportation agencies must work with environmental agencies to assure that planning and implementation conform to air quality standards set forth in the Clean Air Act Amendments (CAAA) of 1990.
- Citizen involvement. ISTEA requires citizen involvement in transportation planning. To link transportation investments more closely to regionally defined goals, ISTEA calls for involving citizens in planning at the most local level and at the earliest stage of the planning process: The intent of subsection 134 is to "integrate planning and environmental requirements at the planning stage so that alternative courses of action, their costs and environmental effects as well as transportation demand are considered at that point."

There are three concerns regarding the institutional capacity of existing organizations: 1) the capacity of state DOTs and environmental agencies to model travel behavior, environmental, land use, economic and social impacts of transportation policies and IVHS applications: 2) the capacity of Metropolitan Planning Organizations (MPO) to apply comprehensive regional approaches in setting transportation priorities; and 3) the capacity of environmental and community groups to understand and effectively communicate how their concerns relate to transportation policy and the application of IVHS technologies.⁴

III) THE CITIZEN WORLD:

In addition to decentralizing transportation planning authority and requiring conformity between transportation and state air quality plans, a major component of ISTEA is enhanced public participation in the planning process, While progress is underway and some cities and states have exemplary programs, public involvement under ISTEA has been criticized for occurring too late in the planning process.' Transportation planning has long been guided by a comprehensive methodology, yet citizen involvement tended to be reactionary rather than strategic. Interest groups react on a project by project basis supporting some projects due to geographically defined economic development benefits, yet adopting a NIMBY response toward other projects.

ISTEA, with its planning requirements for social, environmental and land-use impacts and its cost constrained approach, represents a more strategic approach. To reach the goals of the Clean Air Act Amendments of 1990 (CAAA), ISTEA shifts the focus from tailpipe solutions to transportation control measures.⁶ In doing so, it relies heavily on the local (MPO) planning process to arrive at strategies that reduce trip-making and trip length.

While ISTEA grants citizens a greater opportunity to influence transportation investments, it also conveys greater responsibility; citizens cannot simply blame the federal bureaucrats but are faced with the hard choices necessary to impact congestion and poor air quality with limited resources. The responsibility is magnified because the decentralizing of authority and increased factors to consider in planning by the Metropolitan Planning Organization (MPO) has led to an unprecedented gap between expectations and resources.'

IVHS operational tests are underway in most large cities, but policy discussion is primarily at the national level. Adverse environmental impacts, in particular air quality and energy consumption, are a major concern. The ultimate environmental impact of IVHS is unknown because of the varying technologies which may be deployed and how they fit into the larger transportation infrastructure. However, this uncertainty has not inhibited national environmental interest groups from criticizing the IVHS agenda for overemphasizing cars and the supply side of transportation systems.

These groups, building upon their successes in passage of the Clean Air Act Amendments of 1990, continue to represent the public's concern over environmental impacts of transportation systems. At the policy consultations, numerous participants representing local interests voiced strong concerns about adverse environmental impacts of IVHS and the lack of local input into the planning process.

CHALLENGES TO PUBLIC PARTICIPATION:

Given the stretched planning capacity of MPOs and the technical and institutional complexities of IVHS, public participation will be a challenging endeavor for the following reasons:

First, IVHS entails centralized planning. At a time when ISTEA stresses bottom up (decentralized) planning, IVHS development is primarily a top-down process with funding provided by U.S. Department of Transportation (USDOT) and direction/strategic planning provided by USDOT and IVHS AMERICA. Because of economies of scale in technology development and the related need for a consistent system architecture, this centralized approach is largely unavoidable.

IVHS goals of leveraging private investment and creating an internationally competitive industry focus policy discussion at the federal level. As a result, public participation at the local level is often conceived of in terms of public acceptance or market demand, rather than engaging citizens in long-range technology development discussions. IVHS development has moved toward the identification of user services that reflect customer needs but it is still unclear how local communities will influence technology development." For example, user services and assessments of marketability are primarily defined by private demand (i.e. in-vehicle guidance systems) rather than public demand for an improved environment (i.e. transportation demand management systems, or remote sensing)."

Second, the complexity of IVHS hinders informed public comment. IVHS represents an array of technologies at various levels of development. The latest classification refers to 29 different user services. Some projects are clearly at the research and development phase while others, such as traffic management center refinements, are more accurately thought of as deployment. Unfortunately, the public is largely unfamiliar with IVHS at a time when the majority of states do not expect to expand funding on public participation."

IVHS technologies provide a range of benefits, including safety, congestion relief, more efficient movement of goods and people, and specific air quality improvements. IVHS projects are funded and planned for under a myriad of programs such as IVHS operational tests, the Congestion Mitigation and Air Quality (CMAQ) program, Congressional earmarks, state and city programs and the various management systems of ISTEA. Thus, any assessment of benefits and costs is inherently complex.

Third, it is unclear whether IVHS represents a sophisticated new tool or a transformative technology change. The introduction of IVHS has been characterized as a systems approach that goes beyond simply applying new tools to specific traffic management problems," and yet the relationship to policy development is unclear. Discussions of IVHS applications are often melded with policy options such as road and parking pricing and land use decisions. At the same time, some transportation planners view IVHS as a "tool in the toolbox" that enables achievement of goals defined through the planning process but which should not be singled out for special consideration by citizens or advocacy groups.

Evaluation is affected by which school of thought is adopted. ISTEA requires consideration of environmental impacts at the systems planning stage rather than the project level. While USDOT provides guidance for assessing environmental impacts as part of the operational test evaluation, a methodology for considering systems impacts is lacking, as is a clear sense of how operational test evaluations relate to strategic planning for a particular region." Finally, significant IVHS activity takes place outside of the operational test program, ¹⁴ further complicating evaluation and integration.

PARAMETERS FOR COOPERATION:

In their paper, "Implementing the Intermodal Surface Transportation Efficiency Act of 1991," Gifford et.

al., describe fundamental value differences between a mainstream and a reform coalition that were major players in the unfolding of ISTEA. The mainstream coalition, made up of transportation professionals and related interest groups, primarily values mobility and social choice, while the reform coalition, made up of environmental groups and urban planners, advocates sustainability and livable communities. Despite their differences, both groups supported ISTEA's decentralization of decision-making, confident that their vision will be reflected in the priorities arrived at by local decision-making processes." As a result, ISTEA while revolutionary in terms of planning requirements, leaves resolution of basic value differences to the implementation arena.

Given the many potential uses of IVHS technologies it is not surprising that conflict over appropriate goals has emerged. The mainstream coalition views IVHS as appropriately maximizing system efficiency as directed by ISTEA. The reform coalition sees IVHS development (as presently structured) as counter to the intent of the CAAA to limit system expansion and focus resources on reducing travel.

Competing visions of a transportation future crystallize in the political environment of limited financial resources. For example, Houston environmentalists object to the proportion of public spending on IVHS relative to non-auto alternatives and are especially critically of CMAQ funds going to flow improvement measures. Similarly, some Twin Cities participants contend that "providing infrastructure for bicycle transportation that is fast, safe, and pleasant should be a priority over large IVHS investments."

The mainstream coalition is confident that short-term, micro-level air quality benefits of traffic smoothing will outweigh any additional emissions resulting from induced demand. The reform coalition, weary of weak CAAA enforcement in the past, fears that IVHS will hinder demand management efforts such as aggressive public transportation systems, and land-use and pricing policies.

With empirical data on the induced demand effect of IVHS severely lacking," the conflict persists. USDOT responded to the data gap with the development of a "new generation" of analytical methods designed to simulate induced demand effects." Stark value differences were clearly evident in the policy consultations. For example one participant commented that "IVHS poses the opportunity to maintain a level of tolerance/comfort for all travelers as the population and vehicle miles travelled (VMT) inevitably increase," while another counters that "no supply side investments should be made without a way to control demand."

Several commentators argue that IVHS development needs a more evolved strategic plan which responds to clearly defined benefits. Tom Horan convincingly argues that IHVS development be "benefit nested," meaning that technology development proceed in response to clear policy goals rather than simply to the possibilities inherent in the technology. "*

Horan has suggested the use of a "shadow" 134 process for IVHS projects." Development of the long-range policy plan is potentially an appropriate place for public input regarding IVHS projects. However, IVHS represents a small fraction of spending (although its marginal effects and future spending allocations may be significant): In addition projects tend to be hidden within on-going investments in traffic management systems, making sufficient attention difficult on a crowded MPO agenda.

Daniel Brand takes benefit nesting a step further by defining a methodology to evaluate costs and benefits as part of statewide or city strategic planning process for IVHS.²⁰ Brand suggests that "cost-benefit assessment be conducted by a diverse group of the highest level decision-makers, including agency heads from all the modal transportation agencies, and citizen and environmental group representatives during a half-day process with a technically skilled facilitator." Brand hopes that this process can move the discussion from a search for "false precision" (i.e. too much reliance on inconclusive data) to consensus on strategic direction.

Outside of formal strategic planning programs, environmental interest groups are defining a new vision for the transportation sector. This vision builds on the success of demand management strategies in the energy utility and solid waste sectors over the past several years.²² Integrated resource planning or integrated waste management is used to consider a range of options, including demand management, to provide the service in question. Demand management strategies include variable pricing policies, such as time of day and inclining block rates in the utility sector, and weight based garbage collection and source reduction in the solid waste sector.

In both of these sectors, demand management strategies have benefitted from the increasing internalization of environmental costs through legislation and utility commission rulings. As a result, many states have adopted hierarchies of preferred options that place demand management as the preferred option.²³

Environmental interest groups argue for the use of pricing strategies, including congestion pricing, emissions fees, and cash-out parking to more fully account for environmental costs in the transportation sector. In addition to environmental benefits, pricing policies are advocated to create greater equity between funders and users of the transportation infrastructure. Although pricing policies have the potential to disproportionately impact low-income individuals, targeting of revenues is viewed as a way to overcome this problem.

With the CAAA focus on controlling vehicle miles travelled (VMT) rather than relying on further tailpipe solutions to reach attainment, demand management strategies in the transportation sector are being given increased attention. However, an articulation of the role of citizens in demand side approaches is missing. Many contend that the ethic at the heart of successful recycling and energy conservation programs, whereby citizens become coproducers of the service, an articulation of the transportation sector?

Common Ground: The main area of disagreement between the coalitions in the IVHS arena is over flow improvements. The crux of conflict was captured by a participant at the Portland consultation - "resolve the philosophical conflict between ATMS system efficiency objectives and the need to reduce VMT." Critics of IVHS view flow improvements as capacity expansion and reject them in the absence of direct road pricing. Proponents of IVHS see flow improvements as essential to congestion management systems and a creative alternative toroad-building. While often supportive of pricing in theory, this group often views such policies as out of their purview due to political impediments to implementation.

While differences have been pronounced, areas of agreement may be substantial. Agreement is conceivable on the importance of advanced public transportation systems, and IVHS enabled pricing policies and smooth multimodal connections. Since IVHS projects in non-attainment areas that effectively increase capacity are likely to face legal challenges from environmental interest groups, and the potential of such battles is likely to deter private sector commitment, the IVHS community has a strong incentive to search for an early compromise. Likewise, the environmental coalition may be willing to move toward common ground in lieu of being perceived as Luddites rejecting new technology outright.

The informational nature of IVHS technology presents opportunities for cooperation. The real time information made possible by IVHS places the user in a new, more involved, position. This capacity of IVHS technologies makes possible but doesn't insure advancements in Transportation Demand Measures (TDMs). Given the public's limited understanding, IVHS planning needs to proactively involve citizens in designing new systems. In this way, the technology can be shaped to meet both consumer needs and public goals as defined by involved citizens.

This participatory technology design requires creative new partnerships. There are several examples of successful partnerships between public - private partners and among multiple agencies including: 1) IVHS AMERICA, a public-private partnership, brings together transportation policy leaders, private businesses and academic researchers to guide the development and deployment of advanced transportation technologies; 2) the I-95 Corridor Project involving twelve states from Maine to Virginia, 3) a three-state coalition of MPOs representing Chicago, IL, Milwaukee, WI, and Gary. IN; and 4) the HELP CRESCENT multi-state Commercial Vehicle Operations (CVO) project.

Partnerships between IVHS and the public, which are likely to be equally important to the ultimate success of these technologies, are harder to find. Public participation at the local and national level is far from that prescribed by ISTEA. In the policy consultations we found most participants, including many transportation and environmental officials, to know very little about IVHS. USDOT and IVHS AMERICA, through regional forums and state based chapters, are attempting to increase public input in the planning process. The forums have drawn large audiences, but attendees are far from representative of the key stakeholders. The Region V forum had a striking absence of environmental or community representatives, and sessions addressed technical issues rather than broader questions of how and where to use new transportation technologies.

Minnesota Guidestar (MnDOT's IVHS project) conveys the challenges of involving the public in the early stages of IVHS planning. Guidestar has an extensive committee structure, including an executive committee with representatives of different modes, the state environmental protection agency, and city and county government, which assumes that the interests of citizens will by sufficiently represented. Guidestar also has a transit innovations committee and a partnership with the Downtown, CMAQ funded, Transportation Management Organization that represent new models of cooperation. Still, processes to educate and involve the public in strategic planning have been limited to project-specific focus groups and marketing campaigns.

Through the policy consultations and other involvement with our research, MnDOT officials have become aware of the need for greater representation from the environmental community in IVHS planning. For many in the environmental community, the policy consultation was the first contact with the Guidestar project. And while many remained skeptical of IVHS benefits, they also learned of the transit focus of Guidestar. This educational exchange highlights the importance of a neutral party in facilitating planning for IVHS.

NEW MODELS FOR COOPERATION:

I) Insure Broad Stakeholder Involvement at Early Stage in Planning

IVHS AMERICA has made significant progress in bringing together public and private sector partners. This is appropriate, since IVHS is expected to rely heavily on private investments. However, IVHS AMERICA's ability to foster a broad local discussion among key stakeholders is limited.²⁹ What is needed are local and state based processes for educating stakeholders and moving toward consensus on appropriate projects." Possibilities for increasing public involvement at the local level include: 1) the policy consultation model employed in our study; 2) the Transportation Planning for Livable Communities regional conferences on ISTEA, co-sponsored by the FHWA, the Surface Transportation Policy Projects (STPP) and five other organizations; and 3) citizen juries.

II) Build Coalitions Involving Key Stakeholders

To be successful transportation policy coalitions must include three types of stakeholders, whose interests and perspectives have frequently led to conflicts in the past: 1) Transportation policy makers and planners, who are responsible for setting and implementing federal, state and local transportation policies; 2) Businesses, whose productivity and ability to create and sustain jobs are dependent on an efficient transportation system; and 3) environmenta1 and community interests, who represent societal and citizen concerns about the potential adverse effects of transportation policies on the environment and communities as well as concerns for social equity and accessibility.

An example of such a broad-based coalition emerged in the San Francisco area to advocate congestion pricing, among other transportation policy improvements. In our three case studies, the seeds for such broad-based coalitions exist. In Houston the business community is very much involved in determining transportation policy and the role of IVHS; however, environmental and community interests are just beginning to play a significant role in transportation planning. Portland has a much stronger environmental community which has helped to shape the city's transportation priorities, and strategic planning for IVHS is at an early stage. The Twin Cities has a strong IVHS partnership between the state DOT, businesses and the University of Minnesota's Center for Transportation Studies; however, until recently environmental interests have not been represented in this partnership.

Some examples which may serve as models for future cooperation among transportation planners and environmentalists are:

- Portland's Land Use Transportation and Air Quality (LUTRAQ), which represents an evolving partnership between transportation planners. environmental regulators, environmental interest groups, and land-use planners.
- Houston's Bicycle Alliance, a grass roots organization, which promotes bicycling as a travel option and led to the creation of Houston's mayoral task force on Bicycle Safety and Mobility.

• Twin City's congestion pricing study sponsored by MnDOT and the Metropolitan Council (Twin Cities MPO) which involves a wide range of stakeholders.

III) Fund Public Education

Informed public participation in IVHS planning means investing in public education. Most of the public doesn't have a clue what IVHS is, and marketing alone will not provide for the "informed public comment" required under ISTEA A public IVHS education campaign could also dovetail with the need for greater public understanding of air quality issues. A good model for IVHS is the Los Angeles MPO which recently established public involvement guidelines requiring ten percent of the total planning budget to go toward public outreach programs. 32

The policy consultations used in our study were designed to establish a neutral turf for discussion of the issues related to IVHS and the environment. Participants found the dialogue to be an important educational and consensus building activity. Such regionally based discussions should be encouraged.

IV) Define a Prototype IVHS Bundle for Non-attainment Areas

IVHS AMERICA/USDOT should prioritize IVHS enabled transportation demand management and pricing strategies, and remote sensing technologies in non-attainment areas. Given the systems approach of IVHS. abstaining from policy debates is not appropriate. Any IVHS flow improvements in non-attainment areas should be designed to give non-SOV travel a time priority. Information alone may cause spreading of peak period travel but will not lead to the necessary mode shifts. Hierarchies devised by the solid waste and energy sector provide possible guidance in defining priority technologies.

Given the scarcity of good data on the environmental impacts of IVHS and transportation control measures in general, ³³ data collection on emissions and travel behavior should be a key output of a IVHS non-attainment bundle. Progress toward agreement on methodologies of environmental impacts is essential to the development of a common vision for IVHS development.

v) Test Institutional Arrangements Not Just Technology

IVHS operational tests need to incorporate more institutional issues. The "smart or livable communities" demonstration projects provide examples of institution testing. A participant at the Twin Cities consultation made a similar suggestion in advocating funding of community based technology demonstration projects.

Michael Replogle of the Environmental Defense Fund describes the need to survey public attitudes toward pricing and AVI.³⁴ Such studies may reveal important information about changes in driving habits. A Recent Roper study found that changing driving habits is the last thing the public is willing to do to help the environment. Future surveys that pit competing options for emissions reduction may provide more realistic and hopeful information.

Furthermore, operational tests should consider equity impacts of IVHS investments. The history of community dislocation resulting from the interstate system and Environmental Protection Agency's recent attention to environmental justice demand that equity impacts be integrated into the operational tests in order to build legitimacy for deployment.

Work by the Urban Habitat Program in San Francisco and Surface Transportation Policy Project's Roundtable on Transportation and Social Equity represent early stages of new models for cooperation in this area.

VI) Integrate IVHS Operational Tests With Other On-going Initiatives such as Growth Management, Alternative Fuels Development, Economic Development, and Intermodal Planning

This approach insures broad stakeholder involvement, maximizes resources, and should have synergistic effects. An excellent example of this is the Portland Metro (MPO) 2040 program. Metro is developing a 50-year strategic plan. The first objective will be setting a land use policy and everything else, including IVHS, will be

planned to fit the land-use policy. IVHS was discussed as part of the annual growth management conference in the city.

VII) Encourage Strategic Linkages to Environmental Projects such as the DOE Clean Cities (alternative fuels) Program, the FTA Livable Communities Initiative (transit services and community development), and Bicycle Projects

The breadth of IVHS technologies allows them to play an important role in many areas of transportation. Targeting funds to innovative new programs that directly link transportation and environmental and community goals would strengthen the credibility of IVHS's mission among skeptical parties.

CONCLUSION

IVHS operational tests represent more than basic research and development. Rather they attempt to test promising technologies in real world situations. The informational nature of IVHS technologies demands that users needs and preferences be carefully addressed to maximize effectiveness. Thus, it is imperative that the public gain a greater understanding of the likely costs and benefits of such technologies, and help to shape their deployment.

New planning requirements under ISTEA require local communities to plan for transportation investments in a manner that addresses multiple goals including mobility, accessibility, economic development, environmental quality, community cohesion and social equity. While there are inherent challenges to public involvement in regards to the development of sophisticated technologies such as IVHS, new models for cooperation are beginning to emerge. The majority of these models reflect creative partnerships among public agencies and between public and private organizations. The time is ripe for the formation of new partnerships that directly involve the public in IVHS planning.

If IVHS is to meet its goal of reducing the environmental and energy impacts of surface transportation, attention to these non-technical issues will have to be given as much weight as the engineering of smart cars and smart roads.

Note: Editing throughout the text provided by Candace Campbell, Fellow, State and Local Policy Program. The paper also benefitted from discussions with Ms. Campbell, Barbara Rohde, Gav DeCramer, and Frank Douma of the State and Local Policy Program.

ENDNOTES

I. Several recent papers consider IVHS planning in a regional context. For example, Havinoviski, Glenn N. et al, "Orange County IVHS Study: A Regional Approach to Strategic IVHS Planning, TRB, 73rd Annual Meeting, January, 1994, Washington, D.C., Gifford, Jonathan L. and Talkington, Scott W., "The Impact of Regional Planning and ISTEA on the Implementation of Intelligent Vehicle-Highway Systems: Issues and Early Field Data," IVHS AMERICA, 1994 Annual Meeting, April, Atlanta, GA, and Klein, Hans and Sussman, Prof. Joseph, "Radical Innovation or Incremental Improvement: What is IVHS and How Should it be Organized?" IVHS AMERICA, Atlanta, April, 1994.

Consideration of the public participation process is harder to find. Polk, Amy, "A Consensus Building Process for the Design of a Regional Traffic Center," IVHS AMERICA, 1994 Annual Meeting, April, 1994, Washington, D.C., specifically addresses public involvement in IVHS planning. Horan, Thomas, in "Toward Adaptive IVHS: The Role of Impact Assessments in Guidingthe Development of Advanced Transportation Technologies" raises this issue as well.

- 2. Comments by Secretary of Transportation, Frederico Pena, IVHS AMERICA Conference, Atlanta, GA. April 1994.
- 3. United States Inter-modal Surface Transportation Efficiency Act (ISTEA), Subsection 134 (F), Metropolitan Planning Rules.

- 4. McDowell, Bruce, and Edner, Sheldon, M., "Reinventing Metropolitan and State Institutions for Surface Transportation Planning," Conference on Transportation Planning, Programming, and Finance, Seattle, WA, July 19, 1992.
- 5. Gifford, Jonathan L., Mallett, William J., and Talkington, Scott W., "Implementing the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA): Issues and Early Field Data," Transportation Research Board, Washington, D.C. January, 1994, p. 15. Gifford, et. al. in describing transportation planning by the National Capital Transportation Planning Board, point out that even with a Citizens Advisory Committee, there were complaints that "involvement occurred too late in the process to provide meaningful responses on complex issues. Also, Annette Liebe, Oregon Environmental Council, February 8, 1994, response to State and Local Policy Program, IVHS and the Environment Project, Survey of Environmental Interest Groups in Case-study Cities. raises similar concerns.
- 6. "Clean Air Through Transportation: Challenges in Meeting National Air Quality Standards," A Joint Report from the United States Department of Transportation and the Environmental Protection Agency, August, 1993.. Also, Epstein, L. "Transportation Planning Redux: Once More into the Breach." Urban Land, January, P. 38-41.
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TRACKING THE FUTURE: INTEGRATING IVHS TECHNOLOGIES WITH THE ISTEA MANAGEMENT SYSTEMS

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ABSTRACT

The focus of this discussion is to present an overview of the Intermodal Surface Transportation Efficiency Act (ISTEA) management systems, the key functional areas of Intelligent Vehicle-Highway Systems (IVHS) that will serve to bring them to fruition, and to present the fundamental factors of the management systems that will contribute to the transportation infrastructure through improved energy efficiency and environmental quality. The end result? A vision for a transportation infrastructure that will support fully automated facilities management programs, incorporating advanced adaptive control and planning strategies and offering significant improvements in systems operations and maintenance, while providing an increased potential for energy savings, and a substantial reduction in impacts on our total environment through more efficient use of our resources.

INTRODUCTION

A failing infrastructure, air quality improvement, disrepair, change, emerging technologies, migration paths all of these characterize, in part, the multitude of varying observations of the status of our transportation infrastructure and recent national initiatives for broad-sweeping transportation improvement programs. During the two and one-half years since the enactment of ISTEA, the fundamental purpose of the current legislation, efficiency, has been noticeably absent. Why?

Major technological innovations, unpredictable and changing governmental actions and rapid changes in the **values** and expectations of transportation system users have characterized the environment confronting the industry over recent years.' In this dynamic state, continuing changes in demand, resources, supplies and technology have represented a formidable challenge to the industry and governmental agencies. While the provisions of ISTEA and the Interim Final Rules published in late 1993 in the Federal Register relating to management systems have served to focus attention to the necessity for change in the transportation infrastructure, significant institutional and technological issues that have resulted from early initiatives in the systems arena remain to be resolved. Subsequently, the rate of improvement in the collective efficiency of the system strategy, as initially envisioned immediately following the enactment of ISTEA, is becoming encumbered by a more recent awareness of the complexity of organizational issues associated with national deployment.

THE CHALLENGE

It is becoming crucial that the growing inter-dependence of the individual transportation elements is adequately recognized to meet the challenge of improvingour transportation network. And, most importantly, that the needs of the system users are fulfilled and adequate recognition is given to the user's capacity to adapt to the speed of introduction of change. This recognition, with respect to the evolution of a systems management strategy for the infrastructure, resolves to a need for a more complete understanding of the, interactive relationship of the Clean Air Act Amendments (CAAA) of 1990, the ISTEA of 1991 and the IVHS Act contained therein. The provision of the IVHS Act, with respect to technology applications and information processing in a multi-modal environment, represents the life-line for success of the ISTEA management systems and achievement of significant environmental quality improvements.

Both the CAAA and ISTEA require greater integration of the continuing, cooperative, and comprehensive (3C) transportation and air quality planning processes. With the integrated planning process giving greater consideration to the cumulative social, economic, and environmental effects of transportation plans the role of systems management and demand strategies in the plans and programs is also required in order to preserve the

existing transportation system and to make it more efficient. ISTEA also requires that the transportation plans include a financial plan to demonstrate how the programs can be implemented with anticipated revenues. Difficult decisions and trade-offs will be required during this process and transportation officials are required to more carefully select the programs that are included in the system(s).

SYSTEMS PERSPECTIVE

Concurrent with the on-going development of a national IVHS architecture, initiatives to establish uniform systems management architecture at a national level and consolidate the concerns of the system users need to accelerate and move forward now and become an integral part of the transportation horizon. Once integrated with the IVHS technology applications to address user services, efficient utilization of the capabilities of the management systems will play a key factor in insuring the efficiency of and protecting the substantial societal investments in the transportation infrastructure. Continued development and effective use of simulation models to forecast the effects of environmental impacts of emerging IVHS technology applications is required coincident with systems evaluation.

Air Quality Monitoring and Management System (AQM) and real-time decision support systems development is already leading to significant achievements to optimize urban transportation networks on environmental criteria, rather than efficiency alone. An example is the UROPOL (Urban Road Pollution) model. This model utilizes the transportation network link data for processing in real-time emission and dispersion models.* Other research in the area of predictive models for arterial and local street networks have produced effective macroscopic models for the estimation of delay, energy consumption and emissions.'

Again, real-time data input for the model is dependent on the functional abilities of the IVHS technology applications to collect and process real-time data characterizing the network segments. These and other improved forecasting techniques will serve to minimize organizational resistance to change and foster improved education, communication, participation and involvement by all parties in the industry.

By utilizing the IVHS functions to integrate the six (6) management systems -- highway pavement, bridges, highway safety, traffic congestion, public transportation facilities and equipment, intermodal transportation facilities and systems, and the required traffic monitoring systems -- a macro-perspective will ultimately evolve. With the continued development of expert systems, improvements in data-fusion techniques and relational data bases, this perspective will ultimately resolve to include predictive, pattern recognition system management techniques -- techniques that will be proven, with unparalleled success -- through the interaction of the dynamic data bases for the six management systems and IVHS technology system applications.

INTEGRATED ARCHITECTURE

For long-term success in the new transportation environment, the infrastructure architecture needs to be tailored to efficiently manage both change and stability while providing adequate information to the infrastructure decision-making process as deployment progresses. To accomplish this, the objectives of the integrated IVHS and management systems process need to consider: 1) multi-disciplinary human-resource development in response to the inter-modal philosophy of the current transportation legislation; 2) the development of policy and institutional frameworks for systems integration; 3) the development of an integrated management systems architecture concurrent with the national IVHS architecture initiatives; and 4) process definition for prioritization and integrated system recommendations.

With the achievement of these objectives, improved capabilities and technological advances will continue to improve system efficiency. The achievement of an optimum level of system efficiency will be dependent on the ability to match resources and performance to establish uniformity in operations.

IVHS Elements

In light of rising costs, limited budgets, and escalating resource constraints it is critical that each elemental program management decision is cost effective and that decisions are combined in a manner that leads to an overall

optimum solution. One of the data management tools that has emerged from early deployment initiatives is the utilization of a Geographic Information Systems (GIS). Linked with the real-time data obtained from the IVHS technology areas of congestion priced networks, real-time information exchange networks, fleet management applications, commercial transport regulatory programs, and advanced vehicle diagnostic and control systems, these applications of IVHS technologies will provide the following key benefits: 1) provide data for accurately projecting operations and maintenance costs. thereby facilitating calculations to dealing with adjustments to user fee structuring and rate coverage; 2) define management programs that consider different segments of the system(s) based on important factors such as: user volume, system loadings, historical system degradation, system condition, etc.; 3) ensure full federal funding authorization in compliance with ISTEA mandates; and 4) provide a system by which to report on system related issues to respective agencies as required in a timely and efficient manner.

The management systems will then provide the necessary tools to aid in predicting the rate of system deterioration and forecasting the required funds to keep the system in satisfactory condition. Developing the IVHS technology system applications with a GIS to store and manage the data will provide a powerful tool to visualize the impact of alternatives and help support the decision-making process, linking the planning process with the physical characteristics of the system(s) elements. The user volume and system loading is the primary factor in determining the expected performance of the system and directly affects the planning of operational strategies and rehabilitation alternatives.

System Elements

The management systems should be categorized according to the levels at which they are implemented. At the network level, management refers to managing a network of system segments or links, and developing optimum strategies for operations, maintenance, rehabilitation, and reconstruction (OMRR). The primary objective is to provide information pertinent to establishing network budgets requirements, allocating funds according to priorities and scheduling OMRR actions. At the program, or project, level the primary objective is to provide a first estimate of preferred OMRR action for each program, its cost and expected life cycle.

At a minimum, the following should be included in a network level analysis: 1) information concerning the condition of the network; 2) establishment of OMRR policies: 3) estimation of budget requirements; and 4) determination of network priorities. The most important component of the network level management system is the database of information on the system segments. With this database it is possible to summarize the current condition of the network, determine which segments or elements are operating or performing the best or worst condition, and determine which segment or element is likely to be performing a critical condition in the near future. Once a rating methodology has been determined for the network segment in a system, an evaluation can be made of the condition of the overall system. With this information, the most elementary type of network level systems management can be performed. This is the process of prioritization, or selecting the network segment with top priority. Thus, the function that IVHS technology applications will serve link the elements of the infrastructure, by developing the subsystems to address the following functional requirements: 1) evaluation of current system condition; 2) system performance prediction; 3) network level prioritization; 4) project level design and implementation; and 5) project level economic analysis.

CONCLUSION

Once the IVHS architecture and industry standardization of communication protocols is achieved, productivity, performance, and resulting efficiency in system operations is the aspect of the industry that will receive considerable attention. Due to the recognition of unique future program and network demands, trends have been developing in the industry in recent years, and will continue, to develop innovative approaches to insure optimum efficiency. At that point in the IVHS service life cycle, governmental regulatory influence on IVHS uniformity in systems operations and management for effective information exchange and systems control will have significant impact on the transportation infrastructure.

IVHS technology applications and their role in the assessment of network conditions cannot be overstated, particularly in the area of information processing systems. Accurate and timely information processing of

information is the key component of IVHS as well as infrastructure design for effective internal communications. Considering the multi-billion dollar per year potentials, the cost savings to society, industry, and the environment will be significant.

The market environment is an important contingency that requires monitoring and re-evaluation in considering near-term and future opportunities, however, with continuing legislative and policy support and current industry trends, advanced technology development and applications to the nation's transportation network will be an eventual success. The resources will evolve to satisfy demand. As stakeholder evaluations are performed within the framework of the IVHS Architecture Development Program already underway, policy and regualtion issues are implication areas that require more focused attention. These factors will weigh heavily on the success of effective and efficient program management, however, the extent that the architecture development supports the goals of intermodalism, decentralized decision-making, and improved air quality described in the CAAA and commercial vehicle regualtions⁴ remains for the future.

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Conference Agenda Monday, June 6

8:00 Welcome Tom Horan, Conference Chair

Charge to Participants Dennis Judvcki, Associate Administrator for Safety and Systems Applications, FHWA David Burwell, Pres, "Rails-to-Trails Conservancy"

Philip Shucet, Asst Vice Pres, Michael Baker, Jr. Inc.

8:30 Policy Visions on New Technologies Diverse views on the role of transportation technologies in improving environmental quality, increasing economic productivity and access to opportunities, and renewing a focus on livable communities and regions. Moderated by: Thomas Deen, Executive Director, Transportation Research Board, *Federal Perspectives:* Joseph Canny, DepAsst Secretary for Policy and International Affairs, DOT, and Andrew Otis, Special Assistant to the Assistant Administrator for Policy, Planning and Evaluation, EPA.

Process and Partnerships: Hank Dittmar, Dir, STPP and James Costantino, Executive Dir, ITS America Private Sector Perspective: Elmer Johnson, Partner, Kirkland and Ellis.

10:15 Roundtable Question and Answer

10:45 Status Report and Future Options Three part session that includes, (1) an ITS description, (2) status on implementing ITS programs, and (3) summary of potential impacts on and relationship to other program/policy areas. Introductions by Chris Body, Staff Engineer, ITSA.

"What is ITS?" Video/Slide Presentation Tutorial on ITS, including its many forms, components, and organizations developing and advancing ITS programs. Chris Body, Staff Engineer, ITSA.

Status of ITS Program Status and Initiatives A Summary of current ITS policies, programs, and activities will include a status report on the National ITS Program Plan. William Spreitzer, Technical Director, ITS Program Office, General Motors. and Dennis Judycki. Associate Administrator for Safety and Systems Applications, FHWA

11:45 Lunch *Joseph L. Fisher Memorial Lectures* Introductions by <u>Dr. J.W. Harrington</u>, Dir Graduate Programs in Public Policy, GMU. Lecturers: Fred Krupp, Executive Director, Environmental Defense Fund <u>Lawrence Dahms</u>, Executive Director, Metropolitan Transportation Commission.

1:00 Policy Opportunities and Constraints Most promising ITS strategies identified through presentations of papers and follow on discussions. Moderated by: <u>Lee Munnich</u>, <u>Director</u>, State and Local Policy Program, Hubert H. Humphrey Insitute of Public Affairs, UMinn. Overview of Conference Papers by the moderator

- Toward an Intelligent and Environmentally Sensitive Transportation System <u>Daniel Sperling</u>, Dir, Institute of Transportation Studies, UC Davis
- · Intelligent Transportation Systems for Sustainable Communities <u>Michael Replogle</u>, Co-Director, Transportation Project, EDF.
- Private Sector Aspects to ITS and the Environment Stephen Lockwood, Ferradyne, Systems, Inc.
- Socioeconomic Aspects to ITS <u>Barbara Richardson</u>, Research Scientist, UMTRI

2:15 ITS Applications to Support Environmental Goals

Four major conference papers to be presented. Moderated by: <u>Stephen Crosby</u>, Chairman, Smartroute Systems Inc.

- Multi-modal Scenarios for Achieving Environmental Benefits <u>Sal Bellomo</u>, Principal, Bellomo-McGee.
- · Induced Demand and Related Environmental Aspects to ITS <u>Sergio Ostria</u>, Senior Analyst, Jack Faucett Associates
- · User Acceptance of ITS: An Unknown in the Environmental Equation <u>Carol Zimmerman</u>, ITS Program Manager, Battelle
 - Equity Issues in Applying ITS to the Environment Lisa Saunders, University of Minnesota
- **3:45 Breakout Groups** Discussion groups consider points of convergence and distance between the policy perspectives presented in earlier discussion. Groups identify points of policy interface and consensus.
 - A New Strategies and Technologies
 - B Energy and Environmental Implications
 - C Institutional Issues
 - D Societal Implications
- 5:30 Reception
- **8:00** Authors' Roundtable Presentation and discussion of Conference Papers. Moderated by Candace Campbell.

Tuesday, June 7

- 8:00 **Summary of Breakout Group Discussions** Breakout group Moderators summarize key points and outstanding issues identified. Moderated by: Phil Shucet
- **8:30** Panel Discussion on Policy Analysis and Research Needs Session will identify the state of current knowledge regarding the impacts of ITS, including: Moderated by George Smith. CALTRANS.
- Research Issues <u>Charles Goodman</u>, Office of Policy Development, Transportation Studies Div, FHWA and Cheryl Little, Research and Special Programs, US DOT
- Societal Implications <u>Edith Page</u>, Manager of Federal Programs, Bechtel Corp., and Societal Implications Task Force Chair,
- Environmental Review Process <u>Jon Kessler</u>. Economist, Office of Policy Analysis, EPA
- Policy Implications <u>Lamont Hempel</u>, Asst Prof, for Politics and Economics, Claremont Grad School

9:45 Panel Discussion on Models for Cooperation

Discussants address organizational issues affecting the coordination of environment and ITS policies and programs and consider current approaches as a baseline for discussing opportunities for improving communications between organizations across perspectives.

Moderator Gloria Jeff, Assoc Admin for Policy, FHWA

Discussants - Cynthia Burbank. Chief, Environmental Programs Div, Office of Environment and Planning,

FHWA, <u>Lee Munnich</u>, Dir, State and Local Policy Programs, Hubert H. Humphrey Institute of Public Affairs, UMinn, <u>Hank Dittmar</u>, Dir, STPP, and <u>John Cox</u>, Chairman, Transportation Task Force, <u>Hal Kassoff</u>, Administrator, Maryland State Highway Administration, and <u>Chris Body</u>, Senior

Engineer, ITS America.

II:45 Lunch Speakers: Gloria Jeff, Assoc Admin for Policy, FHWA, Grace Crunican, Deputy Administrator, FTA. Introduced by <u>David Burwell</u>, Pres, "Rails-to-Trails Conservancy"

l:00 Breakout Group Sessions Conferees return to the four discussion groups tasked with formulating an "action plan" of strategies to extend concepts developed in the ITS Program Plan.

- A New Strategies and Technologies
- B Energy and Environmental Implications
- C Institutional Issues
- D Societal Implications

3:00 Action Plan and Open Discussion

Moderated by Christine Johnson, Parson, Brinkerhoff, Quade. and Douglas, Inc.

Group Moderator Presentations:

- A New Strategies and Technologies: <u>Steve Burrington</u>
- B Energy and Environmental Implications: <u>Douglas Ham</u>
- C Institutional Issues: <u>Peggv Tadei</u>
- D Societal Implications: <u>Ellen Williams</u>

Summary: <u>Philip Shucet.</u> Sessions A & B

Edith Page, Sessions C & D

4:00 Conference Summary and Adjournment Tom Horan, Conference Chair

